

REPORT NUMBER 216a-MGA-20-006

SAFETY COMPLIANCE TESTING FOR FMVSS 216a
“Roof Crush Resistance”

2020 BMW 3-SERIES
NHTSA No. C20204100

VIN No. WBA5R1COXLFH53825

Prepared By:
MGA RESEARCH CORPORATION
446 Executive Drive
Troy, Michigan 48083



Test Date: September 21-22, 2020

Report Date: October 7, 2020

FINAL REPORT

PREPARED FOR:

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
ENFORCEMENT
OFFICE OF VEHICLE SAFETY COMPLIANCE
1200 New Jersey Avenue, SE
WASHINGTON, D.C. 20590

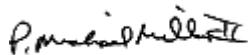
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Prepared By: _____
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Helen A. Kaleto, Laboratory Manager



Approved By: _____
P. Michael Miller II, Vice President

Approval Date: October 6, 2020

FINAL REPORT ACCEPTANCE BY OVSC:

Accepted By: _____
James A. Jones

Acceptance Date: _____
10-7-2020

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. 216a-MGA-20-006	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Final Report of FMVSS 216A Compliance Testing of a 2020 BMW 3-Series, NHTSA No. C20204100		5. Report Date 10/07/2020 6. Performing Organization Code MGA
7. Author(s) Helen A Kaledo, Laboratory Manager Fern Gorman, Project Engineer Jacob Briskey, Test Engineer, Mark Pytell, Test Personnel		8. Performing Organization Report No. 216a-MGA-20-006
9. Performing Organization Name and Address MGA Research Corporation 446 Executive Drive Troy, Michigan 48083		10. Work Unit No.
		11. Contract or Grant No. DTNH22-16-D-00028
12. Sponsoring Agency Name and Address U.S DEPARTMENT OF TRANSPORTATION National Highway Traffic Safety Administration Enforcement Office of Vehicle Safety Compliance 1200 New Jersey Avenue, SE Washington, DC 20590		13. Type of Report and Period Covered Final Test Report 09/21/2020 – 09/22/2020 14. Sponsoring Agency Code NEF-240
15. Supplementary Notes		
16. Abstract Compliance tests were conducted on roof from a 2020 BMW 3-Series, NHTSA No. C20204100, in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure No. TP-216a-00 for the determination of FMVSS 216a compliance. The testing was conducted at MGA Research Corporation in Troy, Michigan on September 21-22, 2020. Test failures identified were as follows: None		
17. Key Words Compliance Testing Safety Engineering FMVSS 216a	18. Distribution Statement Copies of this report are available from: National Highway Traffic Safety Administration Technical Information Services Division, NPO-411 1200 New Jersey Avenue SE (Room E12-100) E-Mail: tis@nhtsa.dot.gov FAX: 202-493-2833	
19. Security Classif. (of this report) UNCLASSIFIED	20. Security Classif. (of this page) UNCLASSIFIED	21. No. of Pages 186 22. Price

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1.0 Purpose of Compliance Test and Test Procedure

Purpose: The tests performed are part of the safety compliance program for the National Highway Traffic Safety Administration (NHTSA) by MGA Research Corporation under Contract No. DTNH22-16-D-00028. The purpose of the testing is to determine whether the subject vehicle, 2020 BMW 3-Series meets certain performance requirements of FMVSS 216a, "Roof Crush Resistance". The compliance test was conducted in accordance with OVSC Laboratory Test Procedure No. TP-216a-00 dated May 6, 2009.

Test Procedures: The "MGA Research Corporation Testing Procedure for FMVSS 216a", submitted to and approved by the National Highway Traffic Safety Administration, contains the specific procedures used to conduct testing.

This procedure shall not be interpreted to conflict with any portion of NHTSA TP-216a-00, FMVSS 216a nor any amendment thereof within the applicable contract.

2.0 Compliance Test Data Summary

The roof of a 2020 BMW 3-Series was required to sustain a maximum load of 46,643.1 N (3 x UVW) on both the right and left sides of the vehicle with platen displacement of 127 mm or less. The left side sustained a maximum load of 46,346 N at 30 mm of platen travel. The right side sustained a load of 47,081 N at 29 mm of platen travel. No head contact was observed.

3.0 Test Data and Results

Data Sheet 1

GENERAL TEST AND VEHICLE PARAMETER DATA

NHTSA No.: C20204100 Test Date: 09/21/2020 Side Tested: Driver/Passenger
Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey

TEST VEHICLE INFORMATION:

Year/Make/Model/Body Style: 2020 BMW 3-Series 4-Door
Body Color: Black VIN: WBA5R1COXLFH53825
Build Date: July 2019 Odometer Reading: 449 miles
Engine Data: 4 Cylinders CID Liter cc
Engine Placement: X Longitudinal or Lateral
Transmission: Speed Manual X Automatic Overdrive
Drive: X Rear Wheel Drive Front Wheel Drive Four Wheel Drive
Safety Restraints: Seat belts and airbags

DATA FROM TIRE SIDEWALL:

Size of the tires on test vehicle: 225/45 R18 Manufacturer: Pirelli
Tire Pressure for Max. Load Carrying Capacity: 340 kPa Front 340 kPa Rear
Treadwear: 500 Traction: A Temperature: A

DATA RECORDED FROM VEHICLE PLACARD OR TIRE LABEL:

Recommended Tire Size: 225/45 R18 XL
Recommended Cold Tire Pressure: 220 kPa Front 260 kPa Rear

VEHICLE CAPACITY DATA:

Number of Occupants	2	Front	3	Rear	5	Total
Type of Front Seats	X	Buckets		Bench		Split Bench
Type of Front Seatback		Fixed	X	Adjustable with		Lever or X Knob

List of Components Removed: Underbody trim, 1st row seats, and carpet

UNLOADED VEHICLE WEIGHT:

Right Front	406.5 kg	Right Rear	393.0 kg		
Left Front	407.0 kg	Left Rear	380.0 kg		
Total Front	813.5 kg	Total Rear	773.0 kg		
Total Weight:	1,586.5 kg	% of Total weight in Front:	51.3	% of Total weight in Rear:	48.7

TEST VEHICLE ATTITUDE:

Pitch Attitude: (Nose Down (ND), Nose Up (NU))
Initial: Right Door Sill Angle 1.1° (ND) Left Door Sill Angle 1.2° (ND)
Final: Right Door Sill Angle 0.1° (ND) Left Door Sill Angle 0.1° (ND)

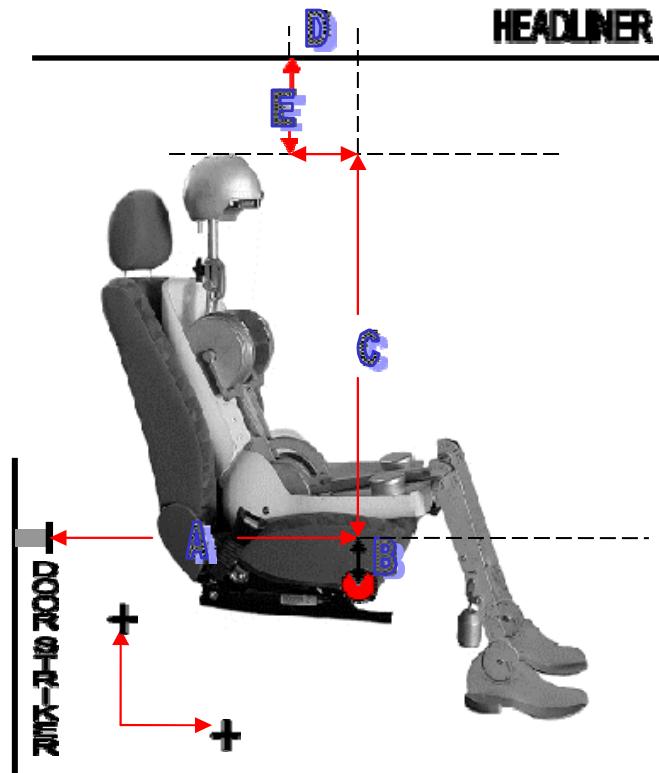
Roll Attitude:

Initial:	Left-side	708	Right-side	705
Final:	Left-side	763	Right-side	760

Jacob Briskey 09/21/2020
Technician Signature Date

Data Sheet 2

NHTSA No.: C20204100 Test Date: 09/21/2020 Side Tested: Driver
 Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell



H-Point Data (mm)

		J826 Only	After HRMD Installed
	Torso Angle	25.2°	25.3°
HRMD	X (=A) – fore/aft of striker	144.5	148.5
	Z (=B) – Above/below striker below	-264.4	-264.9

Positioning Data (mm)

C	487.5
D	174.7
E	102.2

A – Horizontally from the door striker to the H-point

B – Vertically from the H-point to the door striker

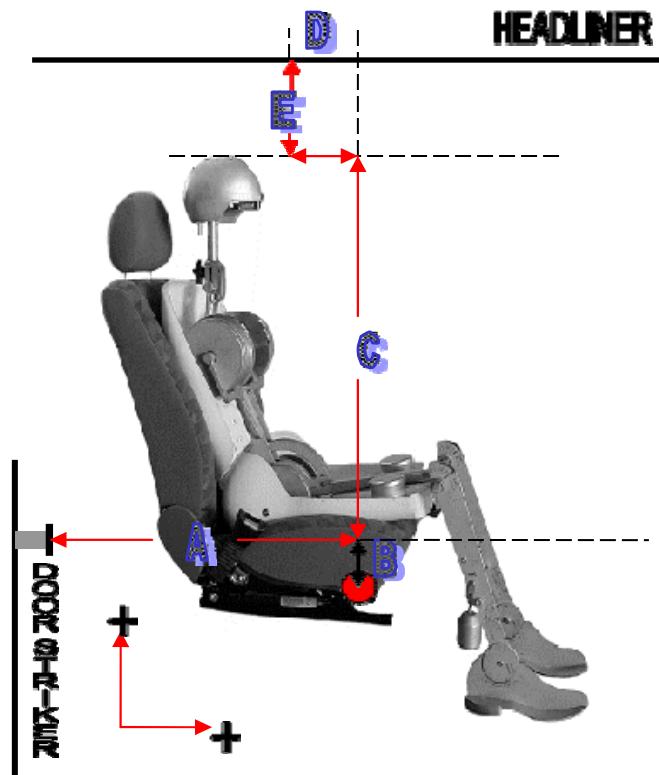
C – Vertically from the door striker to the top of the head

D – Horizontally from the center of the head to the H point

E – Vertically from the top center of the head to the headliner

Data Sheet 3

NHTSA No.: C20204100 Test Date: 09/21/2020 Side Tested: Passenger
 Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell



H-Point Data (mm)

		J826 Only	After HRMD Installed
	Torso Angle	24.8°	25.1°
HRMD	X (=A) – fore/aft of striker	140.3	141.3
	Z (=B) – Above/below striker below	-266.7	-267.5

Positioning Data (mm)

C	486.8
D	168.6
E	109.9

A – Horizontally from the door striker to the H-point

B – Vertically from the H-point to the door striker

C – Vertically from the door striker to the top of the head

D – Horizontally from the center of the head to the H point

E – Vertically from the top center of the head to the headliner

Data Sheet 4

Test Information – First Tested Side

NHTSA No.: C20204100 Test Date: 09/21/2020 Side Tested: Driver
Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell

A. Driver Side Pre-Test Data

Levelness of the Tie-Down Surface/Platform (0 +/- 0.5°): 0.0° Platen

Platen Angles: Pitch Angle: 5° Roll Angle: 25°

Platen Alignment at Vehicle Longitudinal Centerline: 634 mm

Max. Applied Force for Vehicles w/GVWR ≤ 2722 kg = UVW 1,586.5 x 9.8 x 3.0 = 46,643 N

Max. Applied Force for Vehicles w/GVWR > 2722 kg = UVW N/A x 9.8 x 1.5 = N/A N

1. Any convertible top, movable or removable roof structure in their closed positions: Yes

2. Close all windows, close and lock all doors: No Yes X

3. The test device will initially contact the roof at 185 mm aft of windshield.

4. HRMD Top Center of Head Position (Driver): X: -26.3 Y: -394.4 Z: 487.6

5. HPF 201 Head form Top Center of Head Position (Driver): X: -26.2 Y: -394.6 Z: 487.5

HPF device properly aligned: Yes

B. Post Test Data

Maximum load achieved = 46,346 N at 30 mm of displacement.

Did the maximum load achieved reach the maximum applied force (0,-250N)? No-Fail Yes-Pass X

Did head contact occur? No X Yes at mm of displacement

Was a 222 N head resultant force attained? No-Pass X Yes-Fail at mm of displacement.

Did the platen travel exceed 127 mm? No-Pass X Yes-Fail

Did the windshield break? No X Yes at mm of displacement.

Did the sun roof panel(s) break? No X Yes N/A

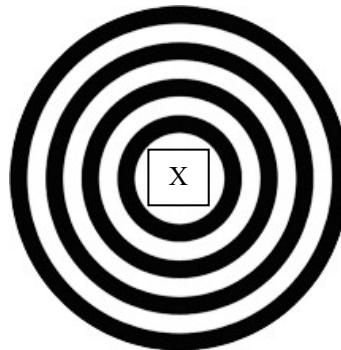
Description of damage and deformation that occurred during the test:

Permanent deformation on upper roof door structure on the driver side.

Data Sheet 4 Continued
Test Information – First Tested Side

Did the second HPF shift from its original position? No Yes Distance _____

Indicate in the picture below where the second HPF center is located versus the original position (center).
NOTE: The distance between each concentric circle is 2 mm.



Data Sheet 5

Test Information – Second Tested Side

NHTSA No.: C20204100 Test Date: 09/22/2020 Side Tested: Passenger
Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell

A. Passenger Side Pre-Test Data

Levelness of the Tie-Down Surface/Platform (0 +/- 0.5°): 0.0° Platen

Platen Angles: Pitch Angle: 5° Roll Angle: 25°

Platen Alignment at Vehicle Longitudinal Centerline: 638 mm

Max. Applied Force for Vehicles w/GVWR ≤ 2722 kg = UVW 1,586.5 x 9.8 x **3.0** = 46,643 N

Max. Applied Force for Vehicles w/GVWR > 2722 kg = UVW N/A x 9.8 x **1.5** = N/A N

1. Any convertible top, movable or removable roof structure in their closed positions: Yes

2. Close all windows, close and lock all doors: No Yes X

3. The test device will initially contact the roof at 185 mm aft of windshield.

4. HRMD Top Center of Head Position (Passenger): X: -27.2 Y: 411.7 Z: 486.7

5. HPF 201 Head form Top Center of Head Position (Passenger): X: -27.3 Y: 411.7 Z: 486.8

HPF device properly aligned: Yes

B. Post Test Data

Maximum load achieved = 47,081 N at 29 mm of displacement.

Did the maximum load achieved reach the maximum applied force (0,-250N)? No-Fail X Yes-Pass

Did head contact occur? No X Yes at mm of displacement

Was a 222 N head resultant force attained? No-Pass X Yes-Fail at mm of displacement.

Did the platen travel exceed 127 mm? No-Pass X Yes-Fail

Did the windshield break? No X Yes at mm of displacement.

Did the sun roof panel(s) break? No X Yes N/A

Description of damage and deformation that occurred during the test:

Permanent deformation on upper roof door structure on the passenger side.

4.0 TEST EQUIPMENT LIST AND CALIBRATION INFORMATION

ITEM	MFR	MODEL	S/N	CALIB. PERIOD	DATE OF LAST CALIB.	ACCURACY
LVDT 1	MTS	G-Series	LVDT 1	12 Months	10/11/2019	0.164%
LVDT 2	MTS	G-Series	LVDT 2	12 Months	10/11/2019	0.164%
LVDT 3	MTS	G-Series	LVDT 3	12 Months	10/11/2019	0.164%
LVDT 4	MTS	G-Series	LVDT 4	12 Months	10/11/2019	0.164%
Load Cell 1	Interface	1220AF-50K	305372	12 Months	12/13/2019	0.93%
Load Cell 2	Interface	1220AF-50K	568559	12 Months	12/14/2019	0.93%
Load Cell 3	Interface	1220AF-50K	281953	12 Months	12/13/2019	0.93%
Load Cell 4	Interface	1220ACK-50K	557637	12 Months	12/13/2019	0.93%
Load Cell 5	Interface	1220ACK-50K	1019124	12 Months	12/13/2019	0.93%
Load Cell 6	Interface	1220AF-50K	305366	12 Months	12/14/2019	0.93%
Load Cell 7	Interface	1220AF-50K	305386	12 Months	12/14/2019	0.93%
HPF Load Cell	Humanetics	9555TF	DH9302	12 Months	10/08/2019	0.20%
Inclinometer	MIT	Pro 360	MGA00173	12 Months	03/16/2020	0.062° + 0.6R
Tape Measure	Stanley	33-215	TPM003-86	12 Months	04/29/2020	1 mm
Force Gauge	Imada	DS2-110	MGA00975	12 Months	11/20/2019	.2%
CMM	FARO	N/A	C12-D2-05-03364	12 Months	07/02/2020	±0.345 mm

MICHIGAN OPERATIONS
DATE: 03/18/2019
SUPERCEDES: MGTP.LVDT.4

DOC. NO.: MGATP.LVDT.CAL
REVISION NO.: 5
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Linear Voltage Displacement Transducer (LVDT)
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT - 1	Name:	Tape measure
Model:	MTS	Model:	Stanley
S/N:	216 - LVDT-1	S/N:	TPM 009 - 37
Range	24"	Capacity:	12"
Calibration Date	10/11/2019	Calibration Date:	03/19/19
Calibration Due Date	10/11/2020	Calibrated By:	Nevastar.

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.52	0.062	Intercept
5.00	5.04	0.164	-0.02
7.50	7.52	0.092	
10.00	10.04	0.164	
12.50	12.54	0.167	
15.00	15.04	0.167	
17.50	17.53	0.125	
20.00	20.04	0.167	
22.50	22.52	0.083	Maximum Error
24.00	24.00	0.000	0.167

*: percent Error calculated by $100 \times (\text{Measured} - \text{Calculated}) / \text{Measured Range}$

Calibrated thermometer (ID# MI 0095) used to monitor temperate and Relative Humidity.

Temperature	% Relative Humidity
68.4°F	39%

Performed By: YBawant

Approved By: 

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is $\pm 0.7\%$.
All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties
expressed at approximately the 95% confidence level using a coverage factor $k=2$.

MICHIGAN OPERATIONS
DATE: 03/18/2019
SUPERCEDES: MGTPLVDT-4

DOC. NO.: MGATP_LVDT_CAL
REVISION NO.: 5
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Linear Voltage Displacement Transducer (LVDT)
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT-2	Name:	Tape Measure
Model:	MTS	Model:	Stanley
S/N	216-LVDT2	S/N:	TPM 0050-37
Range	24"	Capacity:	12"
Calibration Date	10/11/2019	Calibration Date:	03/19/19
Calibration Due Date	10/11/2020	Calibrated By:	Navistar

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.52	0.082	Intercept
5.00	5.00	0.000	-0.01
7.50	7.52	0.092	
10.00	10.00	0.000	
12.50	12.52	0.092	
15.00	15.00	0.000	
17.50	17.52	0.092	
20.00	20.04	0.164	
22.50	22.52	0.092	Maximum Error
24.00	24.00	0.000	0.164

* percent Error calculated by 100*(Measured - Calculated) / Measured Range

Calibrated thermometer (ID# NI0095) used to monitor temperate and Relative Humidity.

Temperature	% Relative Humidity
69.4 F	39.1

Performed By: Yuswant

Approved By: 

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is $\pm 0.7\%$.
All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties
expressed at approximately the 95% confidence level using a coverage factor $k=2$.

MICHIGAN OPERATIONS
DATE: 03/18/2019
SUPERCEDES: MGTP.LVDT.4

DOC. NO.: MGATP.LVDT.CAL
REVISION NO.: 5
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Linear Voltage Displacement Transducer (LVDT)
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT - 3	Name:	Tube Measure
Model:	MTS	Model:	Stanley
S/N	216-LVDT3	S/N:	TPM 009 - 37
Range	24"	Capacity:	12
Calibration Date	10/11/2019	Calibration Date:	03/19/19
Calibration Due Date	10/11/2020	Calibrated By:	Novastar

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.52	0.092	Intercept
5.00	5.00	0.000	-0.01
7.50	7.52	0.092	
10.00	10.04	0.164	
12.50	12.56	0.246	
15.00	15.04	0.164	
17.50	17.56	0.246	
20.00	20.04	0.164	
22.50	22.56	0.246	
24.00	24.00	0.000	Maximum Error
			0.246

* percent Error calculated by $100 \times (\text{Measured} - \text{Calculated}) / \text{Measured Range}$

Calibrated thermometer (ID# MI 0095) used to monitor temperate and Relative Humidity.

Temperature	% Relative Humidity
68.4°F	39%

Performed By: Ybawant

Approved By:

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is $\pm 0.7\%$. All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor $k=2$.

MICHIGAN OPERATIONS
DATE: 03/18/2019
SUPERCEDES: MGTP.LVDT.4

DOC. NO: MGATP.LVDT.CAL
REVISION NO: 5
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Linear Voltage Displacement Transducer (LVDT)
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT-47	Name:	Tape Measure
Model:	MTS	Model:	Stanley
S/N:	216-LVDT 4	S/N:	TPM 005-37
Range	24"	Capacity:	12"
Calibration Date	10/11/2019	Calibration Date:	03/19/19
Calibration Due Date	10/11/2020	Calibrated By:	Navistar

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.49	0.092	Intercept
5.00	5.00	0.000	0.00
7.50	7.52	0.082	
10.00	10.00	0.000	
12.50	12.52	0.082	
15.00	15.00	0.000	
17.50	17.52	0.082	
20.00	20.00	0.000	
22.50	22.52	0.082	Maximum Error
24.00	24.00	0.000	0.082

* percent Error calculated by $100 \times (\text{Measured} - \text{Calculated}) / \text{Measured Range}$

Calibrated thermometer (ID# MT 005) used to monitor temperate and Relative Humidity.

Temperature	% Relative Humidity
68.4°F	39%

Performed By: Yaswant

Approved By: 

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is $\pm 0.7\%$.
All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties
expressed at approximately the 95% confidence level using a coverage factor $k=2$.



17025 Accredited Certificate of Calibration

Certificate #: 4842690008 e



Calibration Laboratory
 Certificate # 1822.81

Acct #:	088470	Manufacturer:	Interface, Inc.
Customer:	MGA Research Corporation	Model:	1220AF-50K
Shipper #:	No Shipper	Description:	Load Cell
Address:	2807 Elliott	Serial Number:	305372A
	Troy, MI, 48083	Asset Number:	
Contact:	Scott Arsen	Barcode:	
PO #:	MI20037		

As Received	As Returned	Action Taken	Cal Date:	12/13/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/13/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Chartered	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb·ft nfg spec. The estimated measurement uncertainty is ± 13 lbf, which represents an expanded uncertainty using a coverage factor ($k = 2$) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of $k=2$ unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, only type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL-STD 45662A, QD-1000-2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory: 

QA Approved:



1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690008

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 305372A

Account Number: 088470
Technician: M. Schneider
Cal. Date: 12/19/2019
ID: 305372A

Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0016	
10000	8.268	8.2636	0.011 %
20000	16.523	16.5255	-0.006 %
30000	24.785	24.7873	-0.006 %
40000	33.052	33.0491	0.007 %
50000	41.310	41.3108	-0.002 %
20000	16.494	16.5255	
0	0.000	0.0016	

Linear Coefficients

A= 1.6428571E-03
B= 8.2620071E-04
C= -3.5714286E-13

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.169 mV
Input Resistance: 351.20 Ohms
Output Resistance: 351.19 Ohms

Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.133 mV		35261.4 lbf	70.5 %



Report Number: 4842690008

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 305372A

Account Number: 88470
Technician: M. Schneider
Cal. Date: 12/13/2019
ID: 305372A

Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0007	
10000	-8.292	-8.2907	0.003 %
20000	-16.582	-16.5823	-0.001 %
30000	-24.875	-24.8755	-0.001 %
40000	-33.170	-33.1703	-0.001 %
50000	-41.467	-41.4667	0.001 %
20000	-16.572	-16.5823	
0	0.000	-0.0007	

Linear Coefficients

A= -6.7857143E-04
B= -8.2891821E-04
C= -8.0357143E-12

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.169 mV
Input Resistance: 351.20 Ohms
Output Resistance: 351.19 Ohms

Shunt Calibration(s)

Electrical Load	- Signal Output	to	- Excitation Simulated Load	Percent of FS
30.000 kOhm	-29.129 mV		35123.1 lbf	70.2 %



17025 Accredited Certificate of Calibration

Certificate #:

4842690009 e

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Calibration Laboratory
 Certificate # 1022.01

Acct #:	088470	Manufacturer:	Interface, Inc.
Customer:	MGA Research Corporation	Model:	1220AF-50K
Shipper #:	No Shipper	Description:	Load Cell
Address:	2807 Elliott	Serial Number:	568559A
	Troy, MI, 48083	Asset Number:	
Contact:	Scott Arsen	Barcode:	
PO #:	MI20037		

As Received	As Returned	Action Taken	Cal Date:	12/14/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/14/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept.:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb-ft mfg spec

The estimated measurement uncertainty is ± 13 lb-ft, which represents an expanded uncertainty using a coverage factor ($k = 2$) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of $k=2$ unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determinations. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL-STD 45662A, QD-1000-2011.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/14/2019

Signatory:

QA Approved:



1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690009

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 568559A

Account Number: 88470
Technician: M. Schneider
Cal. Date: 12/14/2019
ID: 568559A

Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0003	
10000	8.393	8.3932	-0.001 %
20000	16.790	16.7878	0.005 %
30000	25.182	25.1841	-0.005 %
40000	33.582	33.5820	0.000 %
50000	41.982	41.9816	0.001 %
20000	16.786	16.7878	
0	0.000	0.0003	

Linear Coefficients

A= 3.2142857E-04
B= 8.3920607E-04
C= 8.3928571E-12

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.162 mV
Input Resistance: 351.28 Ohms
Output Resistance: 351.15 Ohms

Shunt Calibration(s)

Electrical Load	+ Signal Output	to	+ Excitation Simulated Load	Percent of FS
30.000 kOhm	29.132 mV		34695.8 lbf	69.4 %

Trescal

Report Number: 4842690009

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 568559A

Account Number: 088470
Technician: M. Schneider
Cal. Date: 12/14/2019
ID: 568559A

Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0014	
10000	-8.440	-8.4376	0.006 %
20000	-16.873	-16.8729	0.000 %
30000	-25.307	-25.3074	-0.001 %
40000	-33.739	-33.7410	-0.005 %
50000	-42.175	-42.1737	0.003 %
20000	-16.855	-16.8729	
0	0.000	-0.0014	

Linear Coefficients

A= -1.4285714E-03
B= -8.4366000E-04
C= 4.2857143E-12

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load²)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.162 mV
Input Resistance: 351.28 Ohms
Output Resistance: 351.15 Ohms

Shunt Calibration(s)

Electrical Load	+ Signal Output	to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.089 mV		34486.1 lbf	69.0 %



17025 Accredited Certificate of Calibration

Certificate #:

4842690011 e

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Calibration Laboratory
 Certificate # 1022.01

Acct #: 088470
 Customer: MGA Research Corporation
 Shipper #: No Shipper
 Address: 2807 Elliott
 Troy, MI, 48083
 Contact: Scott Arsen
 PO #: MI20037

Manufacturer: Interface, Inc.
 Model: 1220AF-50K
 Description: Load Cell
 Serial Number: 281953A
 Asset Number:
 Barcode:

As Received		As Returned		Action Taken		Cal Date:	12/13/2019
In Tolerance	X	In Tolerance	X	Full Calibration	X	Due Date:	12/13/2020
Out of Tolerance		Out of Tolerance		Special Calibration		Temperature:	73.00 deg. F
Malfunctioning		Malfunctioning		Oper. Verification		Humidity:	35.00 %
Operational		Operational		Adjusted		Baro. Press.:	
Damaged		N/A		Repaired		Procedure:	DCN 50345
N/A				Charted		Reference:	ASTM E74 (2018) / local
				Returned As Is		Dept:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb·ft wfg spec
 The estimated measurement uncertainty is 13 lbf, which represents an expanded uncertainty using a coverage factor ($k = 2$) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of $k=2$ unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z240.1-1994, ANSI/NCSL Z240.3:2006, MIL-STD 45662A, QD-4000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory:

QA Approved:



1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690011

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 281953A

Account Number: 88470
Technician: M. Schneider
Cal. Date: 12/13/2019
ID: 281953A

Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0006	
10000	8.202	8.2029	-0.002 %
20000	16.424	16.4199	0.010 %
30000	24.651	24.6514	-0.001 %
40000	32.893	32.8976	-0.011 %
50000	41.161	41.1585	0.006 %
20000	16.441	16.4199	
0	0.000	0.0006	

Linear Coefficients

A= 6.4285714E-04
B= 8.1949643E-04
C= 7.3214286E-11

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.019 mV

Input Resistance: 350.97 Ohms
Output Resistance: 350.98 Ohms

Shunt Calibration(s)

Electrical Load	+ Signal Output	to	+ Excitation Simulated Load	Percent of FS
30.000 kOhm	29.097 mV		35345.4 lbf	70.7 %



Report Number: 4842690011

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 281953A

Account Number: 088470
Technician: M. Schneider
Cal. Date: 12/13/2019
ID: 281953A

Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0008	
10000	-8.263	-8.2635	-0.001 %
20000	-16.533	-16.5351	-0.005 %
30000	-24.815	-24.8139	0.003 %
40000	-33.102	-33.1000	0.005 %
50000	-41.392	-41.3933	-0.003 %
20000	-16.524	-16.5351	
0	0.000	0.0008	

Linear Coefficients

A= 8.2142857E-04
B= -8.2607036E-04
C= -3.6250000E-11

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.019 mV
Input Resistance: 350.97 Ohms
Output Resistance: 350.98 Ohms

Shunt Calibration(s)

Electrical Load	+ Signal Output	to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.148 mV		35209.7 lbf	70.4 %



17025 Accredited Certificate of Calibration

Certificate #:

4842690001 e

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Calibration Laboratory
 Certificate #; 1022.01

Acct #: 088470
 Customer: MGA Research Corporation
 Shipper #: No Shipper
 Address: 2807 Elliott
 Troy, MI, 48083
 Contact: Scott Arsen
 PO #: MI20037

Manufacturer: Interface, Inc.
 Model: 1220ACK-50K
 Description: Load Cell
 Serial Number: 557637A
 Asset Number:
 Barcode:

As Received	As Returned	Action Taken	Cal Date:	12/13/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/13/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb·ft mfg spec

The estimated measurement uncertainty is ± 13 lbf, which represents an expanded uncertainty using a coverage factor ($k = 2$) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of $k=2$ unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, into type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCIL Z540-1:1994, ANSI/NCIL Z540.3:2006, MIL STD 45662A, QD-1000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory:

QA Approved:



1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690001

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220ACK-50K
Description: Load Cell
Serial Number: 557637A

Account Number: 88470
Technician: M. Schneider
Cal. Date: 12/13/2019
ID: 557637A

Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0029	
10000	8.263	8.2589	0.010 %
20000	16.525	16.5230	0.005 %
30000	24.793	24.7950	-0.005 %
40000	33.071	33.0751	-0.010 %
50000	41.366	41.3631	0.007 %
20000	16.475	16.5230	
0	0.000	0.0029	

Linear Coefficients

A= 2.8571429E-03
B= 8.2520571E-04
C= 4.0000000E-11

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.28 mV

Input Resistance: 351.47 Ohms
Output Resistance: 351.33 Ohms

Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.134 mV		35214.9 lbf	70.4 %

Trescal

Report Number: 4842690001

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220ACK-50K
Description: Load Cell
Serial Number: 557637A

Account Number: 088470
Technician: M. Schneider
Cal. Date: 12/13/2019
ID: 557637A

Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0023	
10000	-8.324	-8.3197	0.010 %
20000	-16.636	-16.6358	0.001 %
30000	-24.947	-24.9504	-0.008 %
40000	-33.264	-33.2635	0.001 %
50000	-41.576	-41.5753	0.002 %
20000	-16.618	-16.6358	
0	0.000	-0.0023	

Linear Coefficients

A= -2.2857143E-03
B= -8.3181714E-04
C= 7.1428571E-12

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.28 mV

Input Resistance: 351.47 Ohms
Output Resistance: 351.33 Ohms

Shunt Calibration(s)

Electrical Load	Output	+ Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.077 mV		34968.5 lbf	69.9 %



17025 Accredited Certificate of Calibration

Certificate #:

4842690005 e

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Acct #:	088470	Manufacturer:	Interface, Inc.
Customer:	MGA Research Corporation	Model:	1220ACK-50K-B
Shipper #:	No Shipper	Description:	Load Cell
Address:	2807 Elliott	Serial Number:	1019124A
Contact:	Troy, MI, 48083	Asset Number:	
PO #:	Scott Arsen	Barcode:	
	MI20037		

As Received	As Returned	Action Taken	Cal Date:	12/13/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/13/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Top plate bent

Technical Remarks:

The estimated measurement uncertainty is $\pm 13 \text{ lbf}$, which represents an expanded uncertainty using a coverage factor ($k = 2$) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

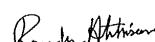
This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of $k=2$ unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL-STD-45662A, QD-4090:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory: 

QA Approved: 

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602

Trescal

Report Number: 4842690005

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220ACK-50K-B
Description: Load Cell
Serial Number: 1019124A

Account Number: 88470
Technician: M. Schneider
Cal. Date: 12/13/2019
ID: 1019124A

Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0031	
10000	8.306	8.3018	0.010 %
20000	16.612	16.6091	0.007 %
30000	24.922	24.9249	-0.007 %
40000	33.245	33.2492	-0.010 %
50000	41.585	41.5819	0.007 %
20000	16.606	16.6091	
0	0.000	0.0031	

Linear Coefficients

A= 3.0714286E-03
B= 8.2945214E-04
C= 4.2500000E-11

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.002 VDC Input Resistance: 351.80 Ohms
Zero Balance: 0.398 mV Output Resistance: 351.65 Ohms

Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.154 mV		35053.5 lbf	70.1 %



Report Number: 4842690005

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220ACK-50K-B
Description: Load Cell
Serial Number: 1019124A

Account Number: 088470
Technician: M. Schneider
Cal. Date: 12/13/2019
ID: 1019124A

Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0016	
10000	-8.343	-8.3398	0.008 %
20000	-16.677	-16.6769	0.000 %
30000	-25.010	-25.0132	-0.008 %
40000	-33.350	-33.3485	0.004 %
50000	-41.683	-41.6829	0.000 %
20000	-16.657	-16.6769	
0	0.000	-0.0016	

Linear Coefficients

A= -1.6428571E-03
B= -8.3385786E-04
C= 4.6428571E-12

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.002 VDC
Zero Balance: 0.398 mV

Input Resistance: 351.80 Ohms
Output Resistance: 351.65 Ohms

Shunt Calibration(s)

Electrical Load	Output	- Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.112 mV		34920.7 lbf	69.8 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690010 e T



Calibration Laboratory

Certificate #: 1022.01

Acet #:	088470	Manufacturer:	Interface, Inc.
Customer:	MGA Research Corporation	Model:	1220AF-50K
Shipper #:	No Shipper	Description:	Load Cell
Address:	2807 Elliott	Serial Number:	305366A
Contact:	Troy, MI, 48083	Asset Number:	
PO #:	Scott Arsen MI20037	Barcode:	

As Received	As Returned	Action Taken	Cal Date:	12/14/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/14/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb-ft mfg spec. The estimated measurement uncertainty is ± 13 lbf, which represents an expanded uncertainty using a coverage factor ($k = 2$) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

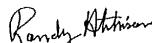
This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of $k=2$ unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCIL Z340.1-1994, ANSI/NCIL Z340.3:2006, MIL-STD 45662A, QD-0000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/14/2019

Signatory: 

QA Approved: 

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690010

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 305366A

Account Number: 88470
Technician: M. Schneider
Cal. Date: 12/14/2019
ID: 305366A

Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0004	
10000	8.261	8.2603	0.002 %
20000	16.520	16.5201	0.000 %
30000	24.780	24.7799	0.000 %
40000	33.039	33.0397	-0.002 %
50000	41.300	41.2996	0.001 %
20000	16.496	16.5201	
0	0.000	0.0004	

Linear Coefficients

A= 4.2857143E-04
B= 8.2598286E-04
C= -3.2607658E-24

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.019 mV

Input Resistance: 350.87 Ohms
Output Resistance: 350.87 Ohms

Shunt Calibration(s)

Electrical Load	Output	Simulated Load	Percent of FS
30.000 kOhm	29.064 mV	35186.4 lbf	70.4 %



Report Number: 4842690010

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 305366A

Account Number: 088470
Technician: M. Schneider
Cal. Date: 12/14/2019
ID: 305366A

Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0004	
10000	-8.305	-8.3064	-0.003 %
20000	-16.614	-16.6126	0.003 %
30000	-24.918	-24.9180	0.000 %
40000	-33.222	-33.2227	-0.002 %
50000	-41.527	-41.5267	0.001 %
20000	-16.609	-16.6126	
0	0.000	0.0004	

Linear Coefficients

A= 4.2857143E-04
B= -8.3072143E-04
C= 3.5714286E-12

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC Input Resistance: 350.87 Ohms
Zero Balance: 0.019 mV Output Resistance: 350.87 Ohms

Shunt Calibration(s)

Electrical Load	+ Signal Output	to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.057 mV		34985.7 lbf	70.0 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690003 e



Calibration Laboratory
 Certificate #: 1022.01

Acet #: 088470
 Customer: MGA Research Corporation
 Shipper #: No Shipper
 Address: 2807 Elliott
 Troy, MI, 48083
 Contact: Scott Arsen
 PO #: MI20037

Manufacturer: Interface, Inc.
 Model: 1220AF-50K
 Description: Load Cell
 Serial Number: 305386A
 Asset Number:
 Barcode:

As Received	As Returned	Action Taken	Cal Date:	12/14/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/14/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Technical Remarks:

Tension base torqued to 55 lb·ft mgf spec before calibration
 The estimated measurement uncertainty is ± 13 lbf, which represents an expanded uncertainty using a coverage factor ($k = 2$) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

12/17/2019
 B

The above identified unit was calibrated in our laboratory at the address shown below.
 This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of $k=2$ unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL-STD 45662A, QD-4000-2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/14/2019

Signatory: Randy Atkinson

QA Approved: QA 31

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690003

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 305386A

Account Number: 88470
Technician: M. Schneider
Cal. Date: 12/14/2019
ID: 305386A

Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0029	
10000	8.246	8.2420	0.010 %
20000	16.485	16.4825	0.006 %
30000	24.722	24.7243	-0.005 %
40000	32.963	32.9674	-0.011 %
50000	41.215	41.2119	0.007 %
20000	16.449	16.4825	
0	0.000	0.0029	

Linear Coefficients

A= 2.9285714E-03
B= 8.2384071E-04
C= 6.7857143E-12

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.056 mV

Input Resistance: 351.45 Ohms
Output Resistance: 351.44 Ohms

Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.123 mV		35330.6 lbf	70.7 %

Trescal

Report Number: 4842690003

Report of Calibration

Manufacturer: Interface, Inc.
Model: 1220AF-50K
Description: Load Cell
Serial Number: 305386A

Account Number: 088470
Technician: M. Schneider
Cal. Date: 12/14/2019
ID: 305386A

Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0012	
10000	-8.282	-8.2798	0.005 %
20000	-16.558	-16.5584	-0.001 %
30000	-24.837	-24.8370	0.000 %
40000	-33.114	-33.1155	-0.004 %
50000	-41.395	-41.3940	0.002 %
20000	-16.548	-16.5584	
0	0.000	-0.0012	

Linear Coefficients

A= -1.1785714E-03
B= -8.2786607E-04
C= 1.7857143E-13

Bridge Connections

(+) Excitation: A
(+) Signal: B
(-) Signal: C
(-) Excitation: D

Deflections = A + (B * Load) + (C * Load^2)

Electrical Data

Excitation: 10.005 VDC
Zero Balance: 0.056 mV
Input Resistance: 351.45 Ohms
Output Resistance: 351.44 Ohms

Shunt Calibration(s)

Electrical Load	Output	+ Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.154 mV		35214.4 lbf	70.4 %



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website: www.humaneticsatd.com

Report Summary



Automated Load Cell Calibration System

Copyright (c)1987-2017 Humanetics Innovative Solutions, Inc. Cert # 2421.03

Customer Name: MGA RESEARCH CORPORATION Identification No.: BF1910081126
33653 DEQUINDRE Date⁴: 10/8/2019
TROY MI 48083

Manufacturer: Humanetics Serial Number: DH9302
Model Number: 9555TF

As Received Condition	As Shipped Condition	Action Taken
In Tolerance ⁵ <input checked="" type="checkbox"/>	In Tolerance <input checked="" type="checkbox"/>	Repair <input type="checkbox"/>
Out of Tolerance <input type="checkbox"/>	Out of Tolerance <input type="checkbox"/>	Full Calibration <input checked="" type="checkbox"/>
Operational <input type="checkbox"/>	Operational <input type="checkbox"/>	Special Calibration <input type="checkbox"/>
Not Operational <input type="checkbox"/>	Not Operational <input type="checkbox"/>	Returned "As Is" <input type="checkbox"/>
Damaged <input type="checkbox"/>	Damaged <input type="checkbox"/>	
N/A <input type="checkbox"/>	N/A <input type="checkbox"/>	
Received Notes	As Shipped Notes	Action Notes
n/a	n/a	n/a

Technical Notes:

1) Unless otherwise noted all calibrations conform to ISO 17025:2005.

Standard ID	Report No.	Serial No.	Due Date	Calibration A2LA Accredited: <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
2K-CL-D2K-1	a912829cf3a74d4fa1c9	571308	3/7/2020	CMC(8) Uncertainty (Force) 0.20% F.S. CMC(8) Uncertainty (Moment) 0.50% F.S.

2) Calibration Standards Used: Standards used in the calibration of this transducer are traceable to NIST (National Institute of Standards and Technology). With exception of the measurements reported on the Load Cell Bridge Impedance Measurement Summary, which are for verification only.

3) Laboratory Scope: Humanetics Innovative Solution, Inc.'s calibration program is accredited to ISO/IEC 17025:2005 ANSI/NCSL Z-540-1-1994.

4) "Date" indicates confirmation of calibration data and should be used to increment calibration intervals.

5) Calibration Methods: The Calibration Methods used in this calibration are defined in the Calibration Method for Single and Multi-Axis Load Cells (CL-WI-00002P), Procedure Number: CL-PR-00001P/CL-PR-00002P.

6) This document applies only to the calibration of the item described above and the specific calibration performed by the Humanetics Innovative Solutions, Inc. calibration laboratory. When declaring in Tolerance or Out of Tolerance condition(s), the calibration laboratory utilizes a Shared Risk Method^{**} as the decision rule. The stability of the UUT over time depends on many factors outside our control. It is the responsibility of those using the item described above to quantify their measurement of uncertainty and evaluate the adequacy of their measurement process to demonstrate that measurement traceability is credibly maintained.

7) This report shall not be reproduced, except in full, without the written consent of the Humanetics Innovative Solutions, Inc.'s calibration laboratory.

8) Calibration and Measurement Capabilities (CMC) represent expanded uncertainties expressed at approximately the 95% level of confidence, coverage factor of $k = 2$.

^{**}The Humanetics Innovative Solutions, Inc. calibration laboratory does not expand the provided measured value(s) by the associated uncertainty of the measurement. When parameter(s) are certified to be within specified tolerance(s), the unexpanded measured value(s) shall fall within the appropriate specification limit. With written agreement from the customer, other decision rules may be used. Please visit the company website at www.humaneticsatd.com for a copy of the Scope and Certificate. A copy of the scope and certificate is also available upon request.

10/10/19



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 email: info@humaneticsatd.com
 website: www.humaneticsatd.com

Calibration Report Uni-Directional Calibration

Automated Load Cell Calibration System
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Applied Excitation (VDC)	10.000	Date	10/8/2019
Calibration No.	BF1910081126	6 Mo. From Cal	4/8/2020
Model No.	9555TF	Serial No.	DH9302
Technician	BURCHI	Temp (°C)	23.1
Customer	MGA RESEARCH CORPORATION	Last Calibrated	Hum. (%) 37.9
Description	3-Channel Load Cell	Customer Tag Number	10/10/2018

Voltage Calibration

Bridge	Capacity	Zero Offset	Nonlinearity	Hysteresis	Output @ Capacity	% Change
FX	2224.1 N	-0.0025 mV/V	0.02 % FS	0.18 % FS	1.7147 mV/V	0.16 % FS
FY	2224.1 N	0.0064 mV/V	0.06 % FS	0.21 % FS	1.7183 mV/V	0.09 % FS
FZ	4448.2 N	0.0199 mV/V	0.05 % FS	0.04 % FS	-1.2413 mV/V	0.18 % FS

Calculated Sensitivity Matrix

Bridge	Capacity	Using Sensor @ 10 V Excitation		Using Sensor @ 5 V Excitation		Using Sensor @ 2 V Excitation		
		Output mV @ Capacity	Output mV/EU	Output mV @ Capacity	Output mV/EU	Output mV @ Capacity	Output mV/EU	
FX	2224.1	N	17.1465	0.00770938	8.5733	0.00385469	3.4293	0.00154188
FY	2224.1	N	17.1830	0.00772580	8.5915	0.00386290	3.4386	0.00154516
FZ	4448.2	N	-12.4128	-0.00278050	-6.2064	-0.00139525	-2.4826	-0.00055810

Shunt

Bridge	Shunt Value	Equivalent Load	Bridge Resistance (nom)
FX	150.0 K Ohms	1529.0 N	700.0 Ohms
FY	150.0 K Ohms	1527.0 N	700.0 Ohms
FZ	200.0 K Ohms	3162.0 N	700.0 Ohms

Note: Positive shunt is between +Exc_+Sig Negative shunt is between -Exc_+Sig

Wire Color Codes

FX	FY	FZ				
Brn	+ Exc	Red Stp	+ Exc	Grn	+ Exc	
Red	+ Sig	Blk	+ Sig	Blu	+ Sig	
N/A	+ Teds	N/A	+ Teds	N/A	+ Teds	
Org	- Exc	Wht	- Exc	Vio.	- Exc	
Yel	- Sig	Blk Stp	- Sig	Gry	- Sig	
N/A	- Teds	N/A	- Teds	N/A	- Teds	

Reference Load Cell

Standard ID	Manufacturer	Model No.	Serial No.	Report No.	Calibration Due Date
2K-CL-D2K-1	Interface, Inc.	1610FMQ-2K-T	571308	a912829cf3a74d4fa1c9	3/7/2020

Calibrated by:

Humanetics Innovative Solutions, Inc. Authorized Representative

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website: www.humaneticsatd.com

Loading Sequence Summary Uni-Directional Calibration

Automated Load Cell Calibration System
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Calibration Number	BF1910081126	Date	10/8/2019
Model Number	9555TF	6 Mo. From Cal	10/8/2020
Serial Number	DH9302	Last Calibrated	10/10/2018
Description	3-Channel Load Cell	Temp (°C)	23.1
Customer	MGA RESEARCH CORPORATION	Customer Tag Number	Hum. (%) 37.9

Loading Sequence

Axis	FS Load	FS Output	Sensitivity	Nonlinearity	Hysteresis	Moment
	EU	mV/V	mV/V/EU	% FS	% FS	Arm EU
FX	2224.1 N	1.714651	0.00077094	0.02	0.18	0
FY	2224.1 N	1.718303	0.00077258	0.06	0.21	0
FZ	4448.2 N	-1.241278	-0.00027905	0.05	0.04	0

Bridge Unbalance

FX Axis	0.0012 mV/V
FY Axis	0.0015 mV/V
FZ Axis	0.0001 mV/V

Linearization

Force (FX)	=	-0.05	+	1297.22	*	Output (mV/V)
Force (FY)	=	-0.57	+	1294.74	*	Output (mV/V)
Force (FZ)	=	-1.04	+	-3583.17	*	Output (mV/V)

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Crosstalk Summary Uni-Directional Calibration

Automated Load Cell Calibration System

Copyright (c)1987-2017 Humanetics Innovative Solutions Inc.

Calibration Number	BF1910081126	Date	10/8/2019
Model Number	9555TF	6 Mo. From Cal	10/8/2020
Serial Number	DH9302	Last Calibrated	10/10/2018
Description	3-Channel Load Cell	Temp (°C)	23.1
Customer	MGA RESEARCH CORPORATION	Customer Tag Number	Hum. (%) 37.9

Crosstalk Data (mV/V)

Bridge	Applied Load	FX	FY	FZ			
FX	2224.1 N	1.714651	-0.006162	0.001837	0.000000	0.000000	0.000000
FY	2224.1 N	0.009423	1.718303	-0.002300	0.000000	0.000000	0.000000
FZ	4448.2 N	0.001186	0.000697	-1.241278	0.000000	0.000000	0.000000

% FS Crosstalk *

Bridge	Applied Load	FX	FY	FZ			
FX	2224.1 N	0.0000%	-0.3586%	-0.1480%	0.0000%	0.0000%	0.0000%
FY	2224.1 N	0.5496%	0.0000%	0.1853%	0.0000%	0.0000%	0.0000%
FZ	4448.2 N	0.0692%	0.0406%	0.0000%	0.0000%	0.0000%	0.0000%

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* Percentage crosstalk for force channels applying moments are corrected for the applied force



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Measurement Report Load Cell Bridge Impedance Measurement Summary

Automated Load Cell Calibration System
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Calibration Number	BF1910081126	Date	10/8/2019
Model Number	9555TF	6 Mo. From Cal	10/8/2020
Serial Number	DH9302	Last Calibrated	10/10/2018
Description	3-Channel Load Cell	Temp (°C)	23.1
Customer	MGA RESEARCH CORPORATION	Customer Tag	Hum. (%) 37.9

Bridge Impedance Measurements*

<u>Axis</u>	<u>Input</u>	<u>Output</u>	
<u>Axis</u>	<u>Impedance</u>	<u>Impedance</u>	
Channel 1 FX	706.0	706.1	Ohms
Channel 2 FY	704.3	706.0	Ohms
Channel 3 FZ	706.1	704.3	Ohms

Bridge High Short Measurement**

<u>Axis</u>	<u>Bridge to</u>	<u>Transducer Body</u>
Channel 1 FX		>=2.00G Ohms (10 ⁹ Ohms)
Channel 2 FY		>=2.00G Ohms (10 ⁹ Ohms)
Channel 3 FZ		>=2.00G Ohms (10 ⁹ Ohms)

Measurement Equipment

National Instruments PXI-4071 Multimeter
Keysight B2965A Electrometer/High Resistance Meter

Measurement Accuracy

±((0.0048 x <reading>) + 0.05 Ohms)2 Years @ 18 to 28°C
±((0.45 x <reading>) + 10⁴ Ohms)/Year @ 23°C ±5°C

*NOTE: Input impedance measurements taken between ±excitation, output impedance measurements taken between ±signal.

**NOTE: High short measurements are taken between ±excitation and the transducer body. Measurements are made at +50.0 VDC.
The measurements reported on this page are for verification purposes only and are not A2LA accredited.

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Calibration Certificate



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Barcode **Certificate #** Z63778:308340

PRO 360 - GENERIC - DIGITAL PROTRACTOR

SERIAL NUMBER:	N/A	WORK ORDER:	308340
ASSET NUMBER:	Z63778	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00173	PERFORMED ON:	03/16/20
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	03/16/21
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	26 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

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AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2076	2076:1438783344	42280 - EXTECH - DATA LOGGER	09/27/2019	09/27/2020
2222	2222:1494506043	550-050 - YUASA - ROTARY TABLE	05/11/2017	05/11/2022

QA Signature:

Date: 3/18/2020 10:28:14 AM



Calibration Certificate



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003



Certificate # Z63778:308340

PRO 360 - GENERIC - DIGITAL PROTRACTOR

SERIAL NUMBER:	N/A	WORK ORDER:	308340
ASSET NUMBER:	Z63778	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00173	PERFORMED ON:	03/16/20
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	03/16/21
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	26 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

AS RECEIVED CONDITION: In Tolerance REMARKS: N/A

AS RETURNED CONDITION: In Tolerance

ACTION TAKEN: FULL CALIBRATION

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2076	2076:1438783344	42280 - EXTECH - DATA LOGGER	09/27/2019	09/27/2020
2222	2222:1494506043	550-050 - YUASA - ROTARY TABLE	05/11/2017	05/11/2022

8488 • J. Neurosci., September 17, 2008 • 28(39):8482–8493

Date: 3/18/2020 10:26:55 AM



Metrology Management Services

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Report Of Calibration



Calibration
#1277.01

PRO 360 - GENERIC - DIGITAL PROTRACTOR

SERIAL NUMBER:	N/A	WORK ORDER:	308340
ASSET NUMBER:	Z63778	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00173	PERFORMED ON:	03/16/20
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	03/16/21
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	26 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

REMARKS: N/A

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2076	2076:1438783344	42280 - EXTECH - DATA LOGGER	09/27/2019	09/27/2020
2222	2222:1494506043	550-050 - YUASA - ROTARY TABLE	05/11/2017	05/11/2022

Test Procedure Results

Test results for calibration with work order : 308340

Test Description	Nominal	Test Result	Limit (Lower)	Limit (Upper)	Units	Uncertainty	Pass/Fail
LINEARITY CHECK							
0° REFERENCE	0.0	0.0	-0.1	0.1	"	0.062" + 0.6R	Pass
5°	5.0	4.9	4.9	5.1	"	0.062" + 0.6R	Pass
30°	30.0	29.8	29.8	30.2	"	0.062" + 0.6R	Pass
60°	60.0	60.0	59.8	60.2	"	0.062" + 0.6R	Pass
90°	90.0	89.9	89.9	90.1	"	0.062" + 0.6R	Pass
60°	60.0	60.0	59.8	60.2	"	0.062" + 0.6R	Pass
30°	30.0	29.9	29.8	30.2	"	0.062" + 0.6R	Pass
5°	5.0	4.9	4.9	5.1	"	0.062" + 0.6R	Pass
0°	0.0	0.1	-0.1	0.1	"	0.062" + 0.6R	Pass
5°	5.0	5.0	4.9	5.1	"	0.062" + 0.6R	Pass
30°	30.0	29.9	29.8	30.2	"	0.062" + 0.6R	Pass
60°	60.0	59.9	59.8	60.2	"	0.062" + 0.6R	Pass
90°	90.0	90.0	89.9	90.1	"	0.062" + 0.6R	Pass
60°	60.0	59.9	59.8	60.2	"	0.062" + 0.6R	Pass
30°	30.0	30.0	29.8	30.2	"	0.062" + 0.6R	Pass
5°	5.0	5.1	4.9	5.1	"	0.062" + 0.6R	Pass
0°	0.0	0.1	-0.1	0.1	"	0.062" + 0.6R	Pass
ABSOLUTE ZERO ANGLE	0.0	0.1	-0.1	0.1	"	0.062" + 0.6R	Pass

- END OF REPORT -



Calibration Certificate



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

||||||||||| Certificate # Z106680:312657

33-215 - STANLEY - 12' TAPE MEASURE

SERIAL NUMBER:	N/A	WORK ORDER:	312657
ASSET NUMBER:	Z106680	TEST RESULT:	PASS
CUST ASSET NUMBER:	TPM003-86	PERFORMED ON:	04/29/20
PROCEDURE NAME:	STA - 33-215 - MMC	CAL DUE DATE:	04/29/21
PROCEDURE REV:	1.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Anthony Barbera	TEMPERATURE:	20 °C
CUSTOMER:	MGA RESEARCH CORP 2927B ELLIOT AVENUE TROY, MI 48083	HUMIDITY:	41 %
PRIMARY CONTACT:	MATT EJAK		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

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AS RECEIVED CONDITION:	Other (See Remark)	REMARKS:	Manufacturers specs not available, data charted for customers use.
AS RETURNED CONDITION:	Other (See Remark)		
ACTION TAKEN:	DATA CHARTED		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1606	1606:1193650836	C635-1800 - L.S. STARRETT - STEEL RULE	04/26/2013	04/26/2028
2077	2077:1438783393	42280 - EXTECH - DATA LOGGER	09/12/2019	09/12/2020

QA Signature: *Be McCormaughay* Date: 4/29/2020 7:30:28 PM

5/5/2020
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Report Of Calibration



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

33-215 - STANLEY - 12' TAPE MEASURE

SERIAL NUMBER:	N/A	WORK ORDER:	312657
ASSET NUMBER:	Z106680	TEST RESULT:	PASS
CUST ASSET NUMBER:	TPM003-86	PERFORMED ON:	04/29/20
PROCEDURE NAME:	STA - 33-215 - MMC	CAL DUE DATE:	04/29/21
PROCEDURE REV:	1.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Anthony Barbera	TEMPERATURE:	20 °C
CUSTOMER:	MGA RESEARCH CORP 2927B ELLIOT AVENUE TROY, MI 48083	HUMIDITY:	41 %
PRIMARY CONTACT:	MATT EJAK		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

REMARKS: Manufacturers specs not available, data charted for customers use.

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1606	1606:1193650836	C635-1800 - L.S. STARRETT - STEEL RULE	04/26/2013	04/26/2028
2077	2077:1438783393	42280 - EXTECH - DATA LOGGER	09/12/2019	09/12/2020

Test Procedure Results

Test results for calibration with work order : 312657

Test Description	Nominal	Test Result	Limit (Lower)	Limit (Upper)	Units	Uncertainty	Pass/Fail
3500mm TAPE MEASURE							
700mm	700	700	N/A	N/A	mm	1.0E-2 m	Pass
1400mm	1400	1400	N/A	N/A	mm	1.0E-2 m	Pass
2100mm	2100	2100	N/A	N/A	mm	1.0E-2 m	Pass
2800mm	2800	2800	N/A	N/A	mm	1.0E-2 m	Pass
3500mm	3500	3500	N/A	N/A	mm	1.0E-2 m	Pass

- END OF REPORT -



Calibration Certificate



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003



Certificate # Z66550:291742

IMADA DS2-110 DIGITAL FORCE GAGE

SERIAL NUMBER:	297462	WORK ORDER:	291742
ASSET NUMBER:	Z66550	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00975	PERFORMED ON:	11/20/19
PROCEDURE NAME:	Force Gage	CAL DUE DATE:	11/20/20
PROCEDURE REV:	4.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	WILLIAM FRENCH	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	31 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a $K=2$. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated, the unit under test results are expressed in the most significant

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

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AS RECEIVED CONDITION: In Tolerance REMARKS: N/A
AS RETURNED CONDITION: In Tolerance
ACTION TAKEN: FULL CALIBRATION

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1633	1633:1193663229	RICE LAKE CLASS 6 17 PC. WEIGHT SET	07/16/2019	07/16/2020
1960	1960:1324551206	RICE LAKE CLASS 6 5 PC. WEIGHT SET	01/31/2019	01/31/2020
2116	2116:1455281491	EXTECH 42280 DATA LOGGER	03/11/2019	03/11/2020
2201	529030000003900	RICELAKE CLASS 6 11 PIECE WEIGHT SET	05/16/2019	05/16/2020

QA Signature: Joe McCaughey Date: 11/20/2019 9:56:07 AM



Metrology Management Services

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Report Of Calibration



Calibration
#1277.01

IMADA DS2-110 DIGITAL FORCE GAGE

SERIAL NUMBER:	297462	WORK ORDER:	291742
ASSET NUMBER:	Z66550	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00975	PERFORMED ON:	11/20/19
PROCEDURE NAME:	Force Gage	CAL DUE DATE:	11/20/20
PROCEDURE REV:	4.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	WILLIAM FRENCH	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	31 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

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REMARKS: N/A

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1633	1633:1193663229	RICE LAKE CLASS 6 17 PC. WEIGHT SET	07/16/2019	07/16/2020
1960	1960:1324551206	RICE LAKE CLASS 6 5 PC. WEIGHT SET	01/31/2019	01/31/2020
2116	2116:1455281491	EXTECH 42280 DATA LOGGER	03/11/2019	03/11/2020
2201	529030000003900	RICELAKE CLASS 6 11 PIECE WEIGHT SET	05/16/2019	05/16/2020

Test Procedure Results

Test results for calibration with work order : 291742

Test Description	Nominal	Test Result	Limit (Lower)	Limit (Upper)	Units	Uncertainty	Pass/Fail
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UUT range is 0 - 110 LBS

UUT Tolerance is $\pm 0.2\% + 0.1\text{LBS}$

Local gravity correction factor is 0.999662

Tension

0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass
21.99LBS	21.99	22.1	21.7	22.3	Lbs	7.2e-002	Pass
43.99LBS	43.99	44.1	43.7	44.3	Lbs	7.4e-002	Pass
65.98LBS	65.98	66.1	65.7	66.3	Lbs	7.7e-002	Pass
87.97LBS	87.97	88.1	87.7	88.3	Lbs	7.9e-002	Pass
109.96LBS	109.96	110.0	109.6	110.3	Lbs	8.1e-002	Pass
87.97LBS	87.97	88.0	87.7	88.3	Lbs	7.9e-002	Pass
65.98LBS	65.98	66.0	65.7	66.3	Lbs	7.7e-002	Pass
43.99LBS	43.99	43.9	43.7	44.3	Lbs	7.4e-002	Pass
21.99LBS	21.99	21.9	21.7	22.3	Lbs	7.2e-002	Pass
0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass

Compression

0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass
21.99LBS	21.99	22.0	21.7	22.3	Lbs	7.2e-002	Pass
43.99LBS	43.99	44.0	43.7	44.3	Lbs	7.4e-002	Pass
65.98LBS	65.98	66.0	65.7	66.3	Lbs	7.7e-002	Pass
87.97LBS	87.97	88.0	87.7	88.3	Lbs	7.9e-002	Pass
109.96LBS	109.96	110.0	109.6	110.3	Lbs	8.1e-002	Pass
87.97LBS	87.97	88.0	87.7	88.3	Lbs	7.9e-002	Pass
65.98LBS	65.98	65.9	65.7	66.3	Lbs	7.7e-002	Pass
43.99LBS	43.99	43.9	43.7	44.3	Lbs	7.4e-002	Pass
21.99LBS	21.99	21.9	21.7	22.3	Lbs	7.2e-002	Pass
0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass

Metric

Tension

49.880 kg	49.880	49.90	49.77	49.99	kg	8.1e-002	Pass
489.10 N	489.10	489.3	488.0	490.2	N	8.1e-002	Pass

Compression

49.88kg	49.880	49.90	49.77	49.99	kg	8.1e-002	Pass
489.10 N	489.10	489.3	488.0	490.2	N	8.1e-002	Pass

- END OF REPORT -

5.0 Photographs



2020 BMW 3-Series
NHTSA No. C20204100

Front view of vehicle
Before testing

FMVSS No. 216a



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

3/4 right front view of vehicle
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Right view of vehicle
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Right side interior front seating area
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

3/4 right rear view of vehicle
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Rear view of vehicle
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

3/4 left rear view of vehicle
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Left view of vehicle
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Left side interior front seating area
Before testing



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

3/4 left front view of vehicle
Before testing



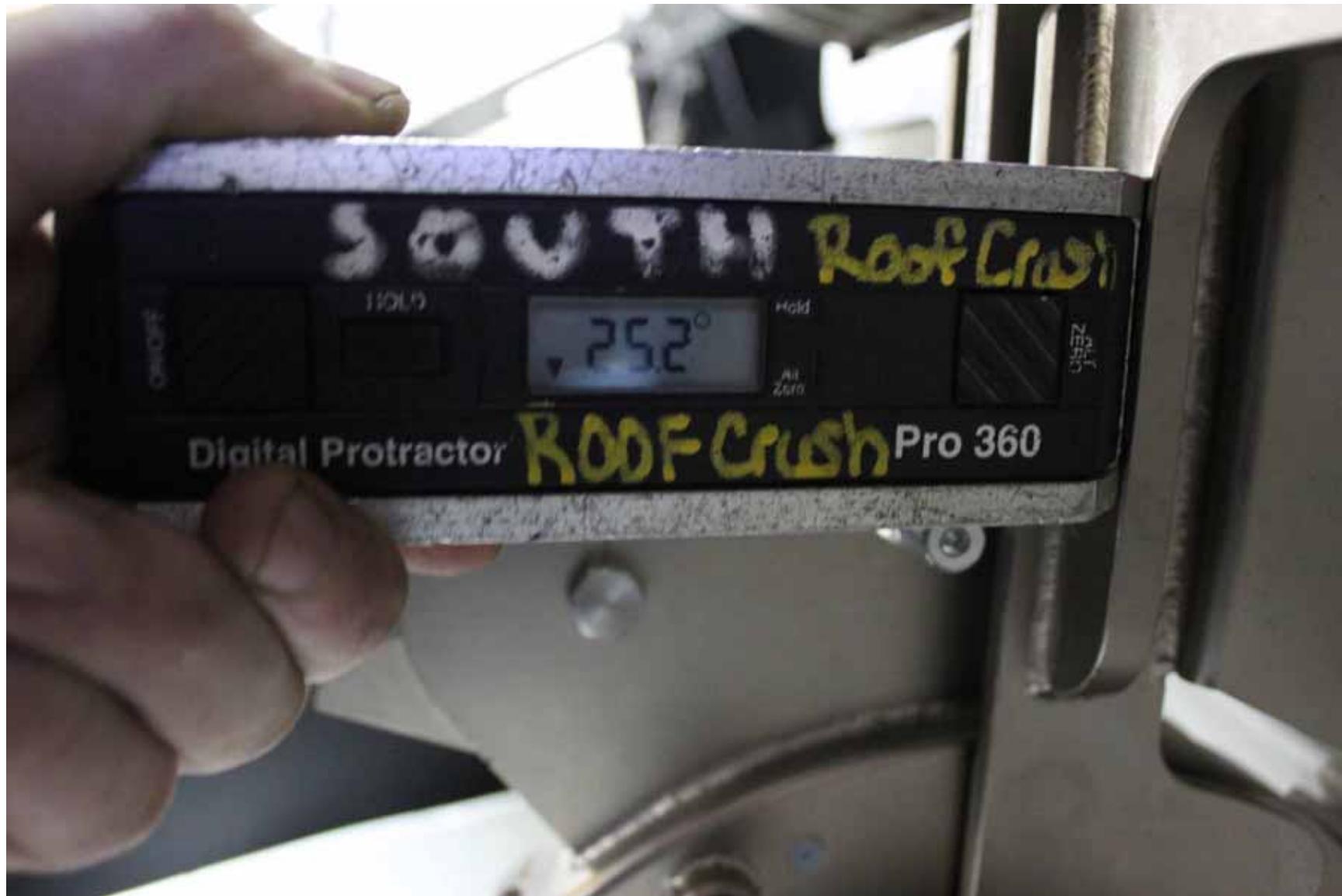
2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 1



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 2



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 3



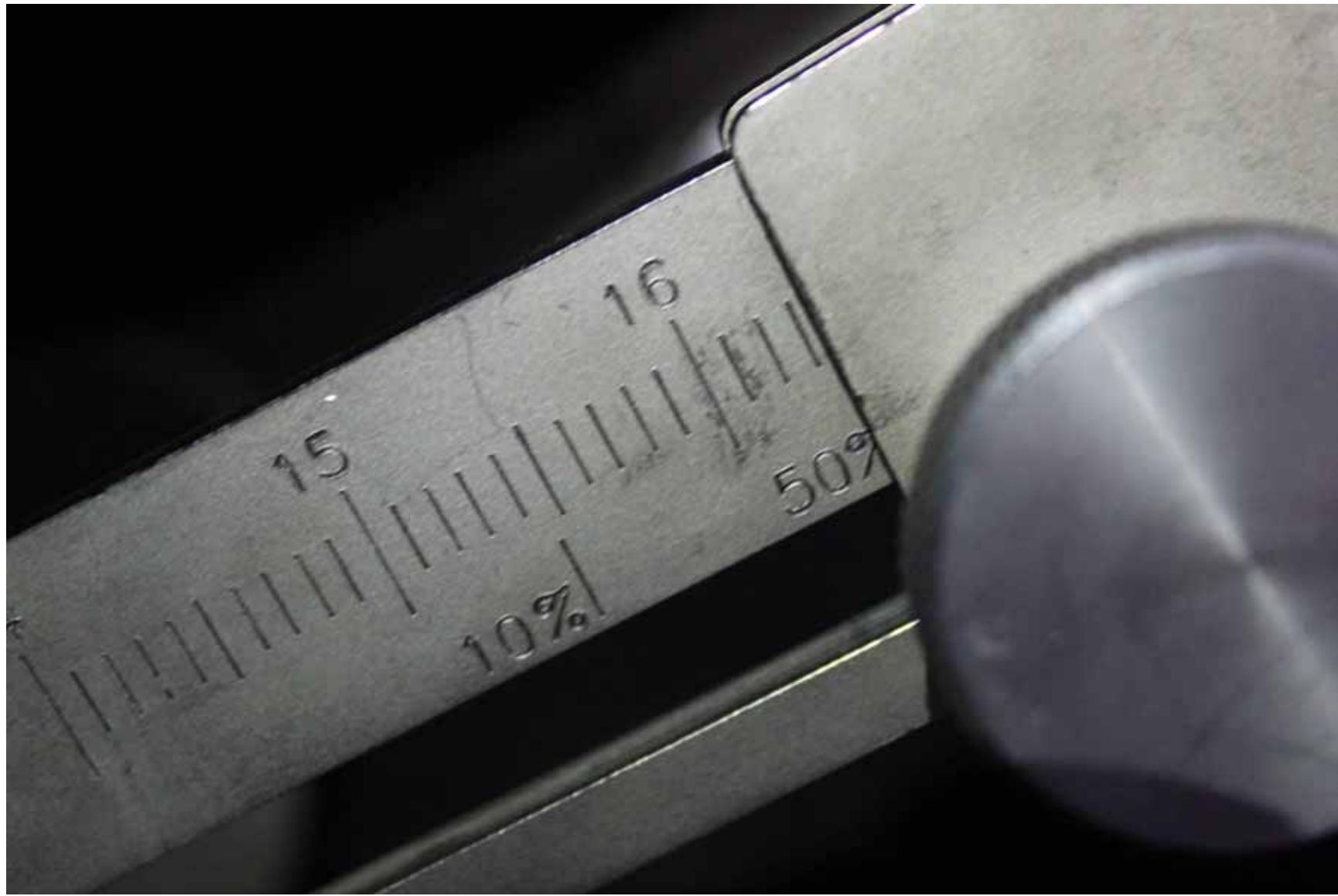
2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 4



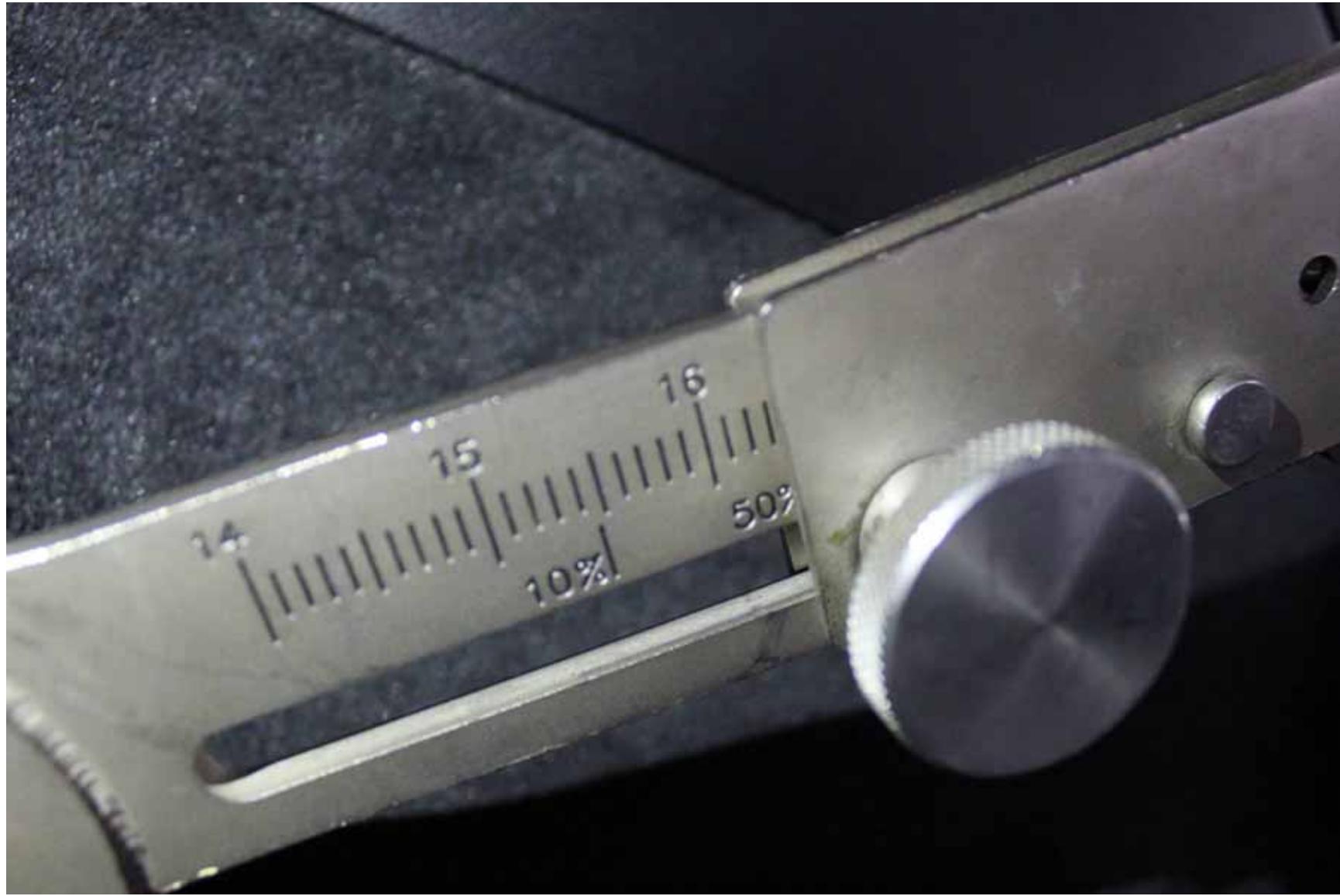
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NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 5



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 6



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 7



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Driver Side Oscar Photograph No. 8



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 1



2020 HYUN BMW DAI 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 2



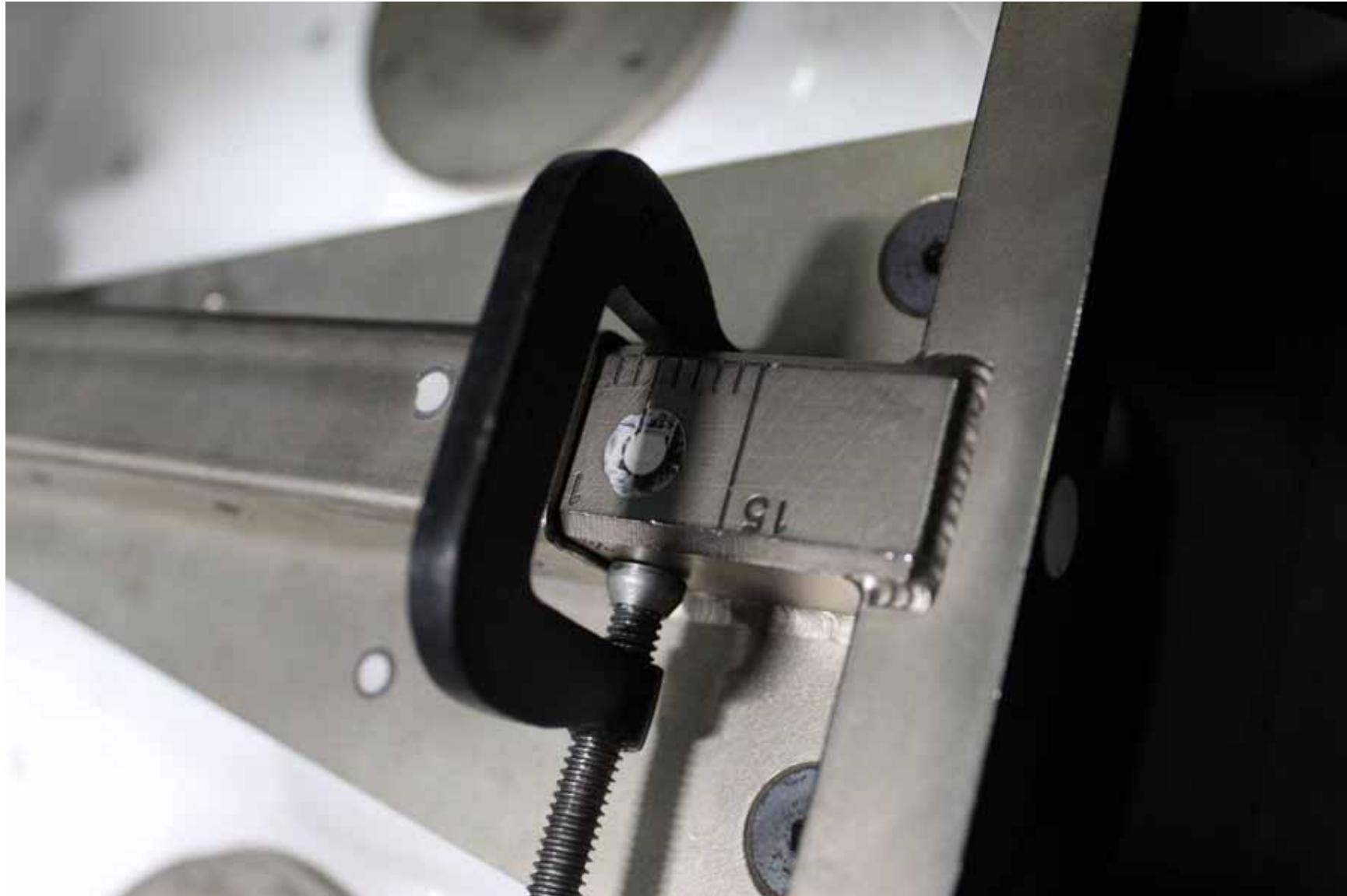
2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 3



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 4



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 5



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 6



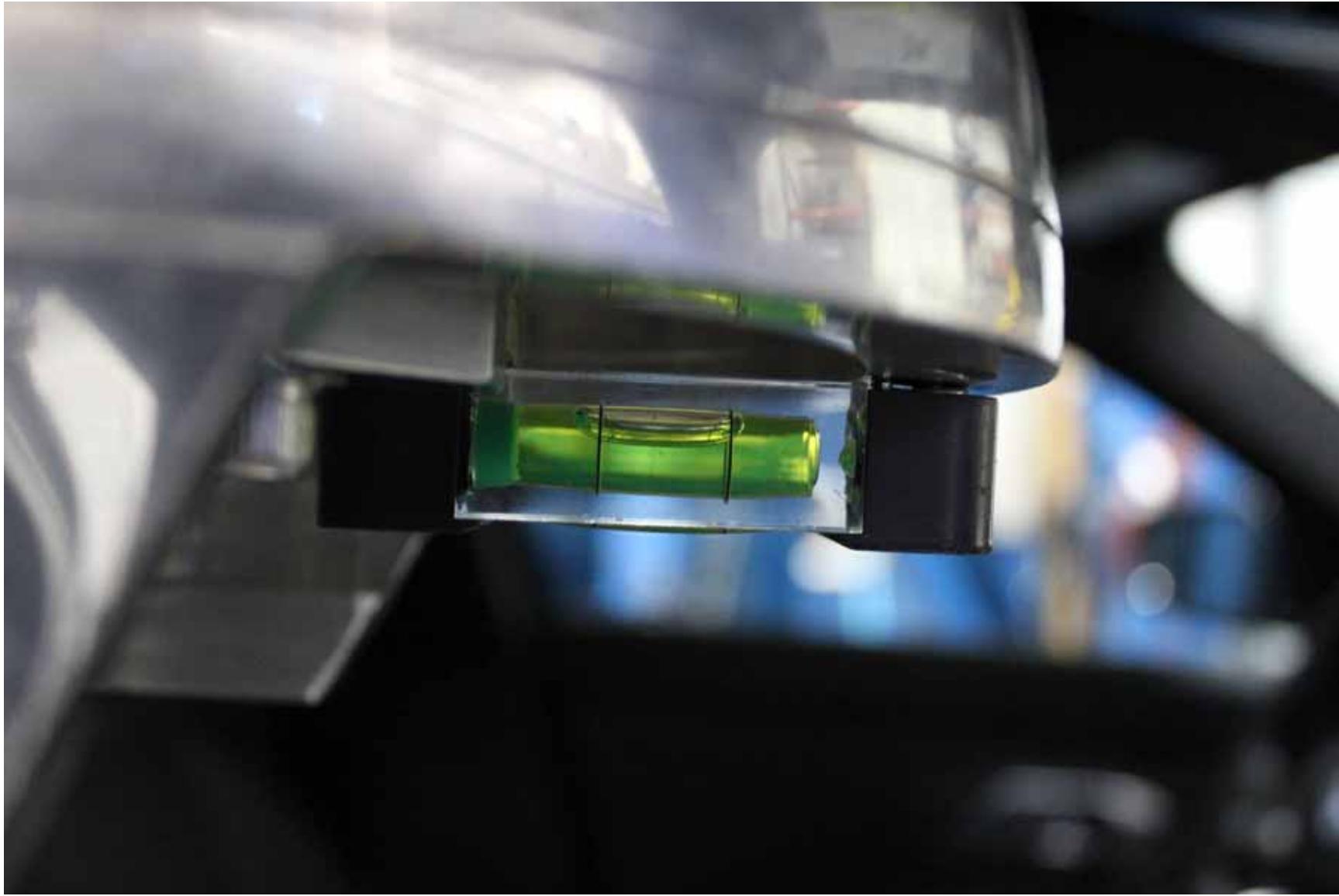
2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 7



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 8



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Passenger Side Oscar Photograph No. 9



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

VIN Label Photograph No. 1





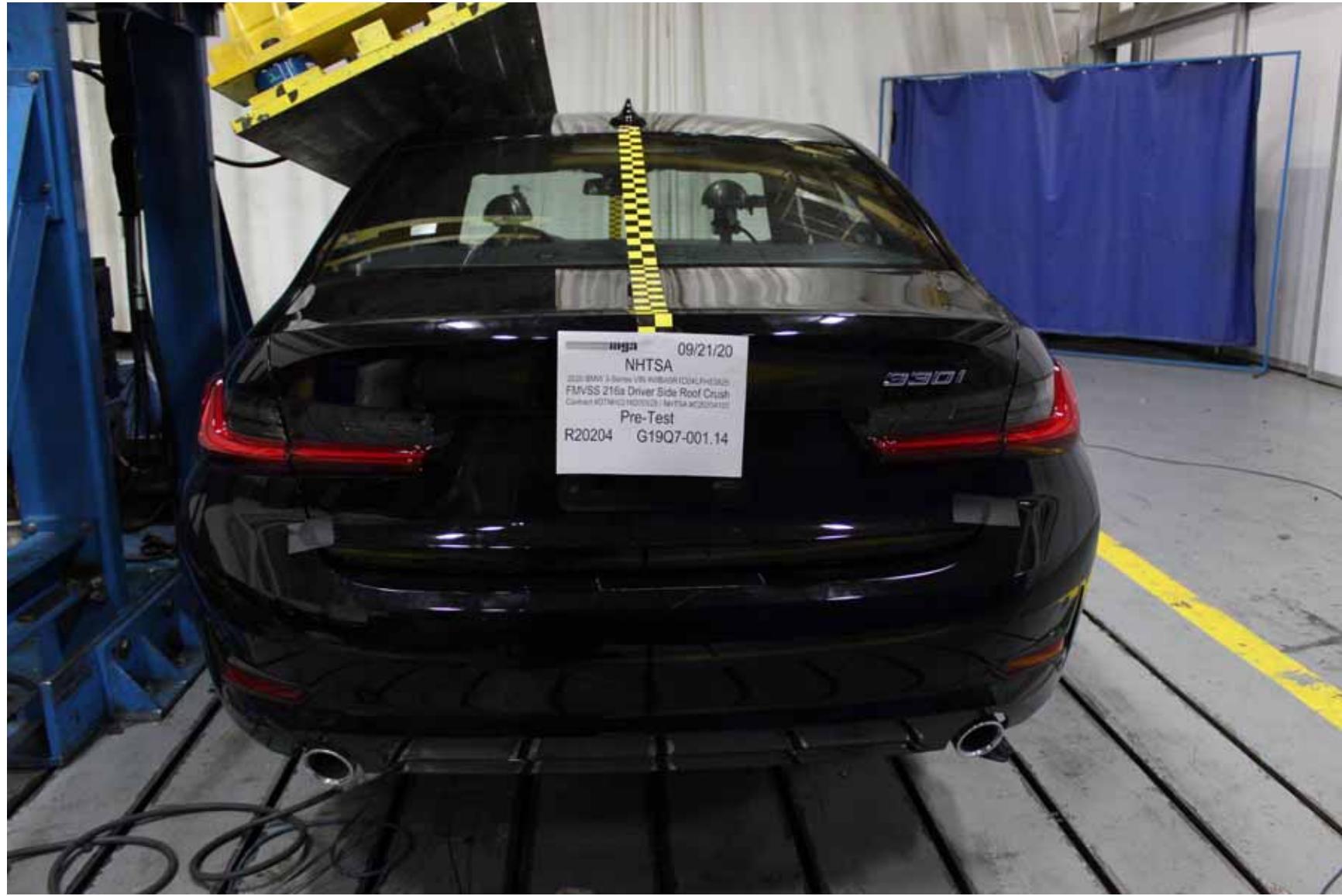
2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 1 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 2 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 3 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 4 of Test R20204



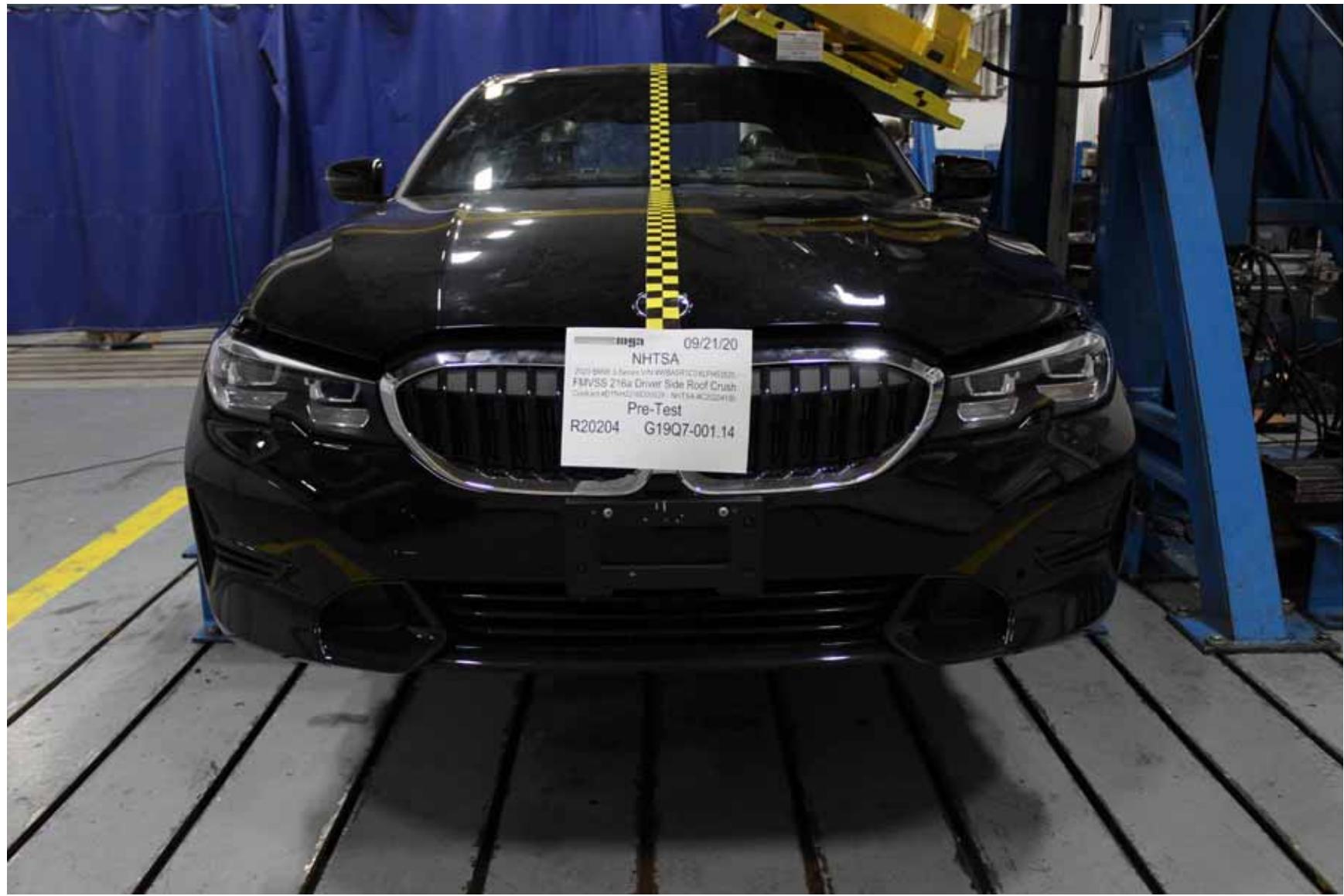
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NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 5 of Test R20204



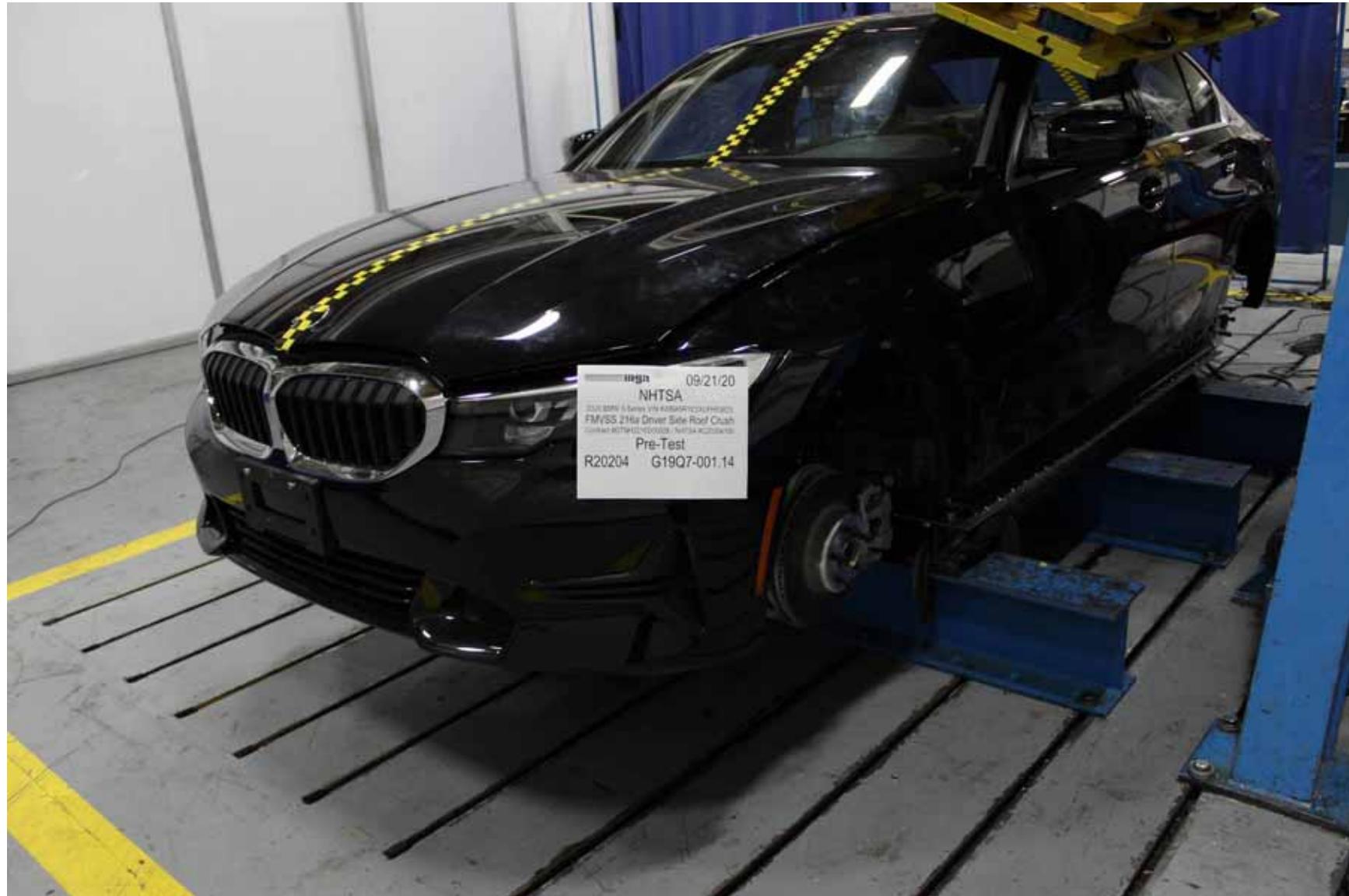
2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 6 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 7 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 8 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 9 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 10 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 11 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 12 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 13 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 14 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 15 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 16 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100

Pre-Test Photograph No. 17 of Test R20204

FMVSS No. 216a



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 18 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100

Pre-Test Photograph No. 19 of Test R20204

FMVSS No. 216a



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 20 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 21 of Test R20204



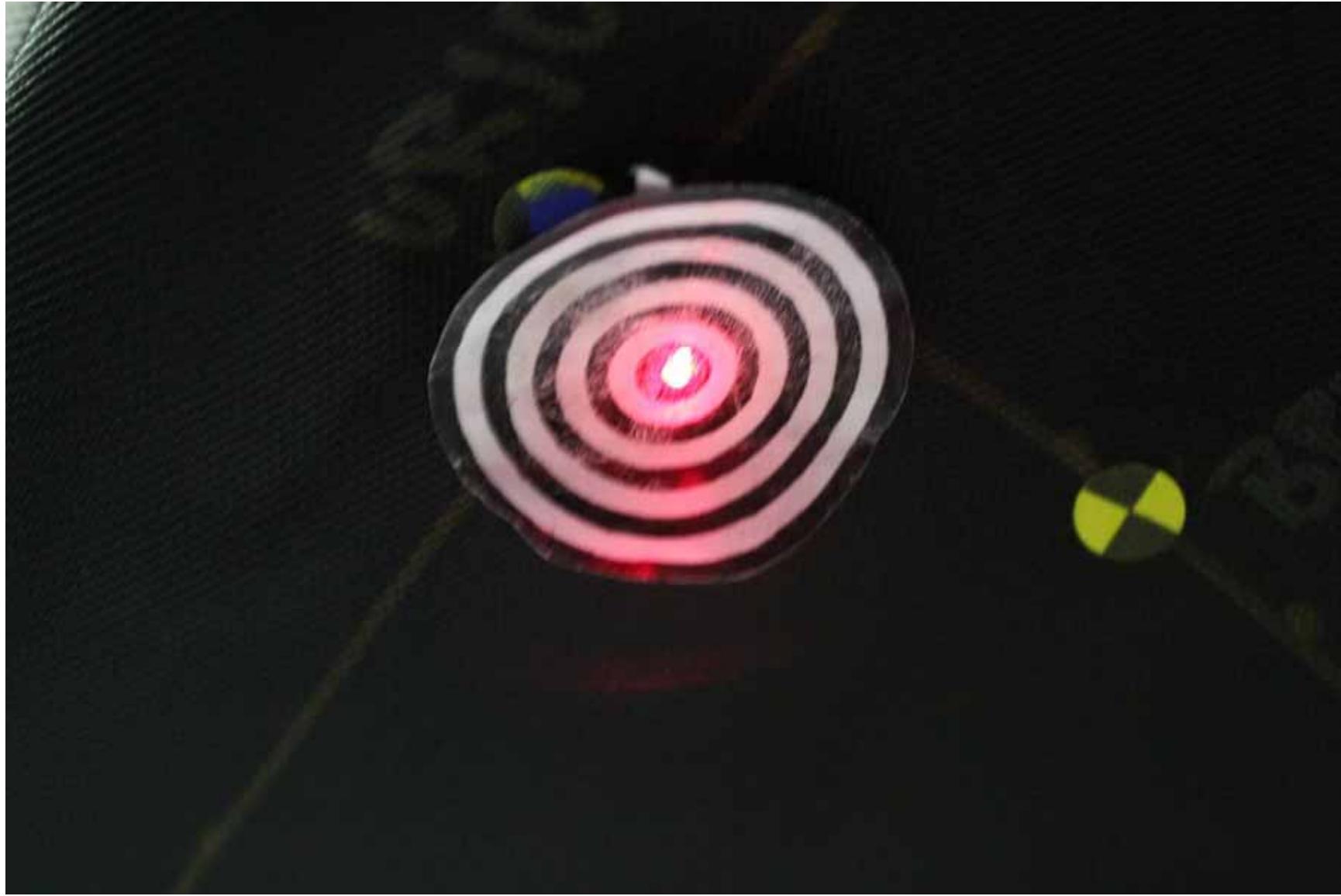
2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 22 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 23 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 24 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 25 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 26 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 27 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 28 of Test R20204



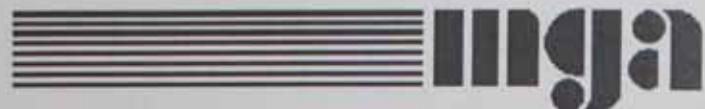
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FMVSS No. 216a

Pre-Test Photograph No. 29 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 30 of Test R20204



09/21/20

NHTSA

2020 BMW 3-Series VIN #WBA5R1C0XLFH53825

FMVSS 216a Driver Side Roof Crush

Contract #DTNH2216D00028 / NHTSA #C20204100

Post-Test

R20204

G19Q7-001.14



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 2 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 3 of Test R20204



2020 BMW 3-Series
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FMVSS No. 216a

Post-Test Photograph No. 4 of Test R20204



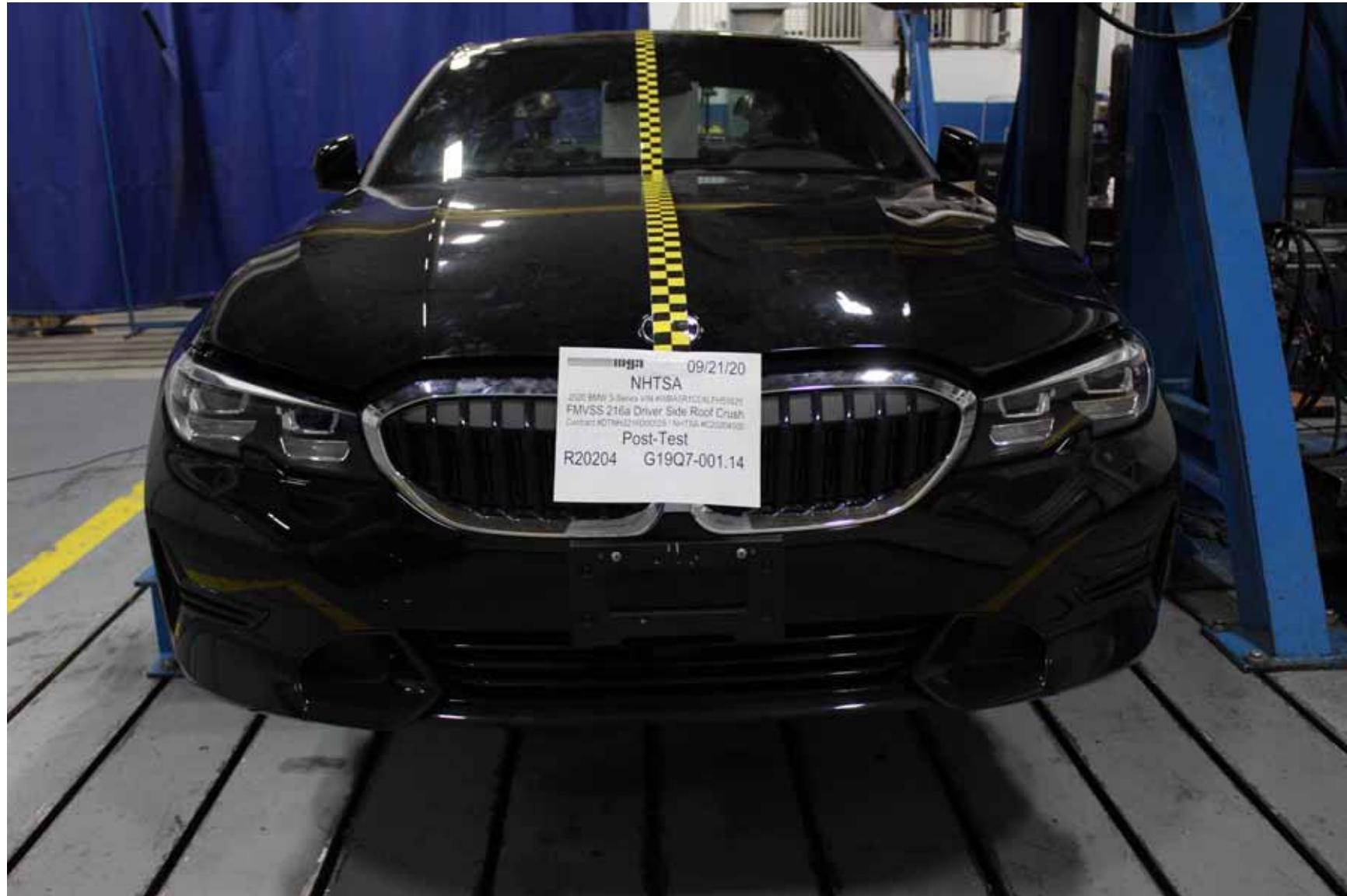
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FMVSS No. 216a

Post-Test Photograph No. 5 of Test R20204



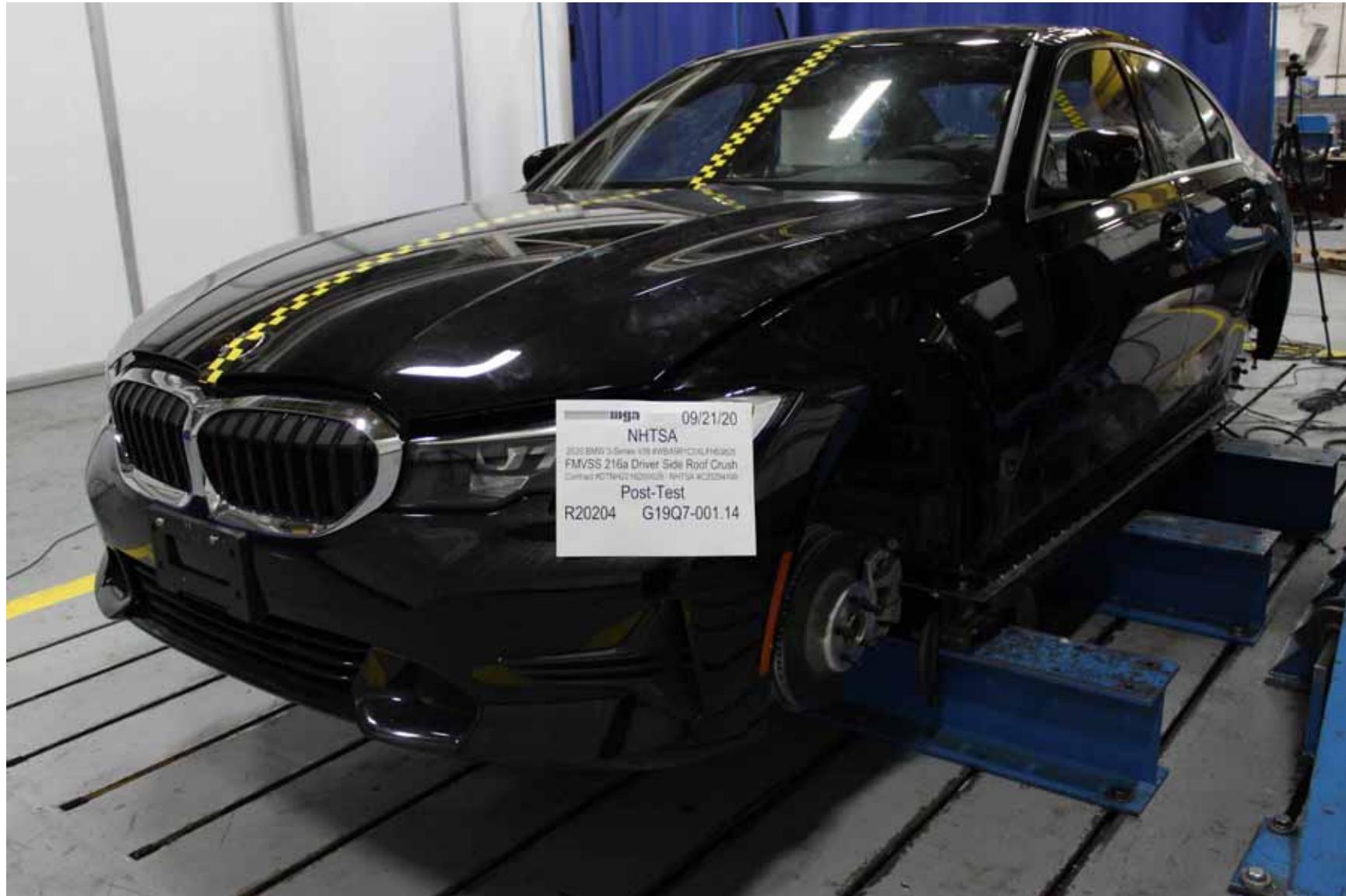
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FMVSS No. 216a

Post-Test Photograph No. 6 of Test R20204



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Post-Test Photograph No. 7 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 8 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 9 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 10 of Test R20204



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FMVSS No. 216a

Post-Test Photograph No. 11 of Test R20204



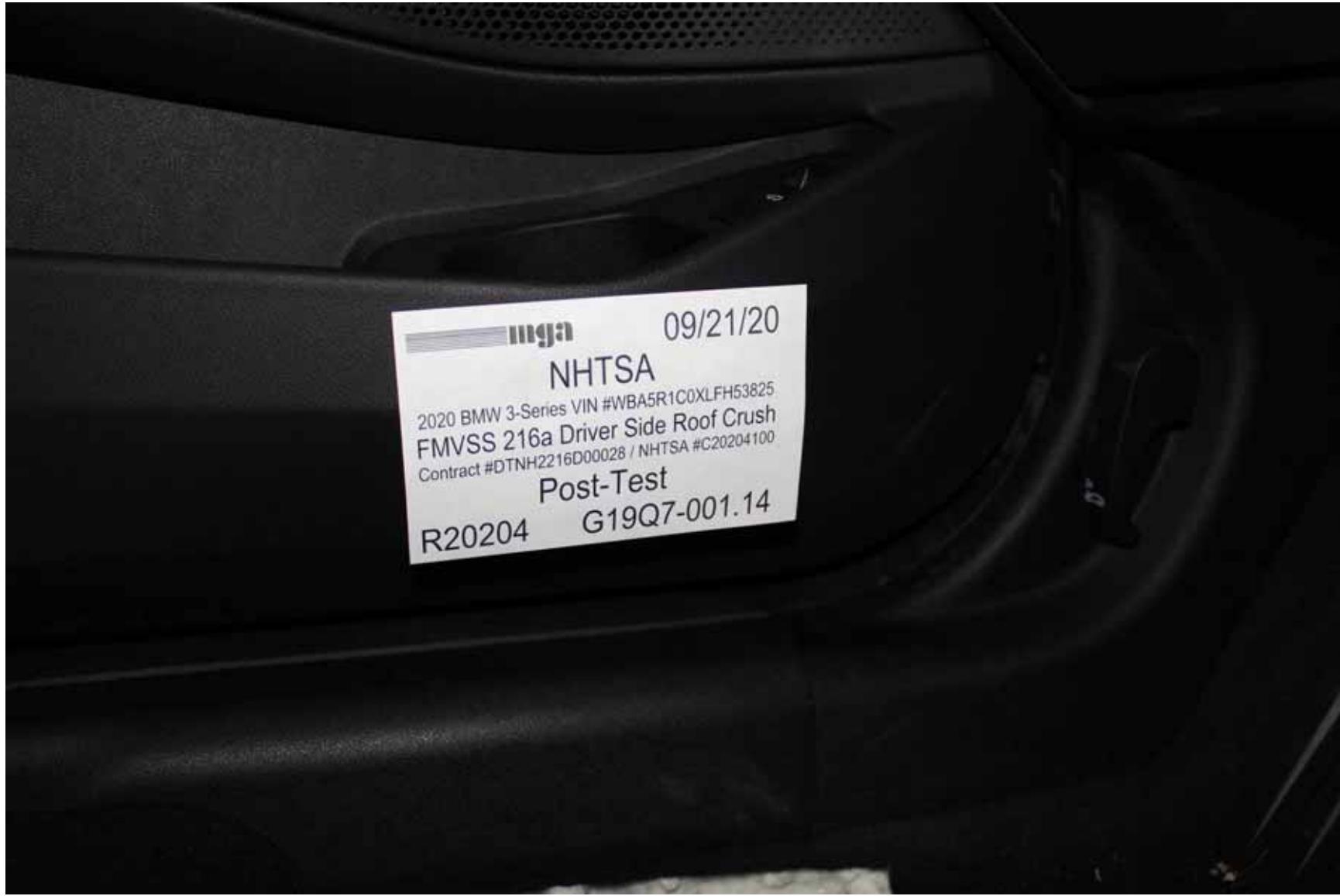
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NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 12 of Test R20204



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FMVSS No. 216a

Post-Test Photograph No. 13 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 14 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 15 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 16 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 17 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 18 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 19 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 20 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 21 of Test R20204



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NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 22 of Test R20204



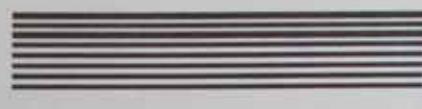
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FMVSS No. 216a

Post-Test Photograph No. 23 of Test R20204



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 24 of Test R20204

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09/22/20

NHTSA

2020 BMW 3-Series VIN #WBA5R1C0XLFH53825
FMVSS 216a Passenger Side Roof Crush
Contract #DTNH2216D00028 / NHTSA #C20204100

Pre-Test

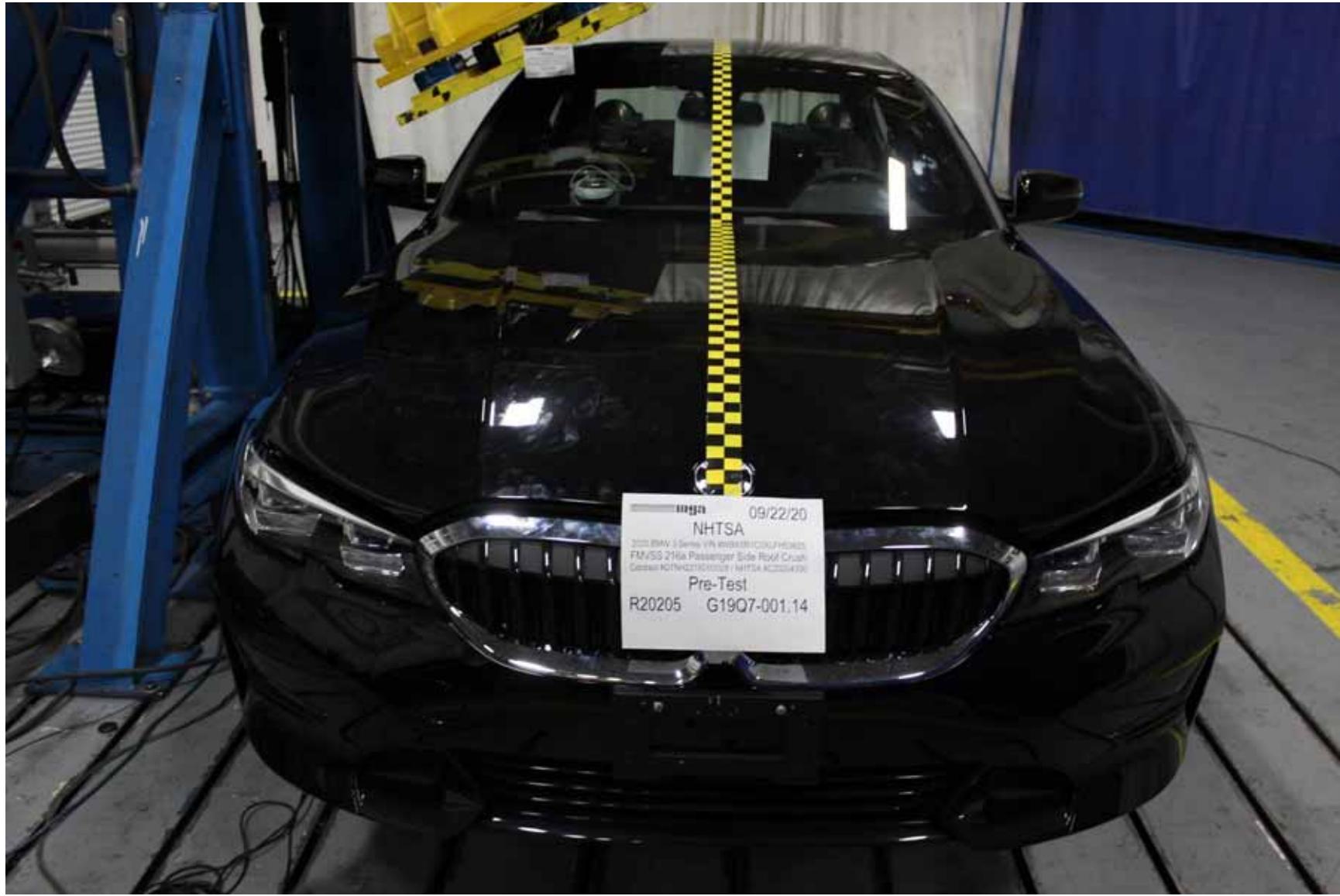
R20205

G19Q7-001.14



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 2 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 3 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 4 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 5 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 6 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

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NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 8 of Test R20205



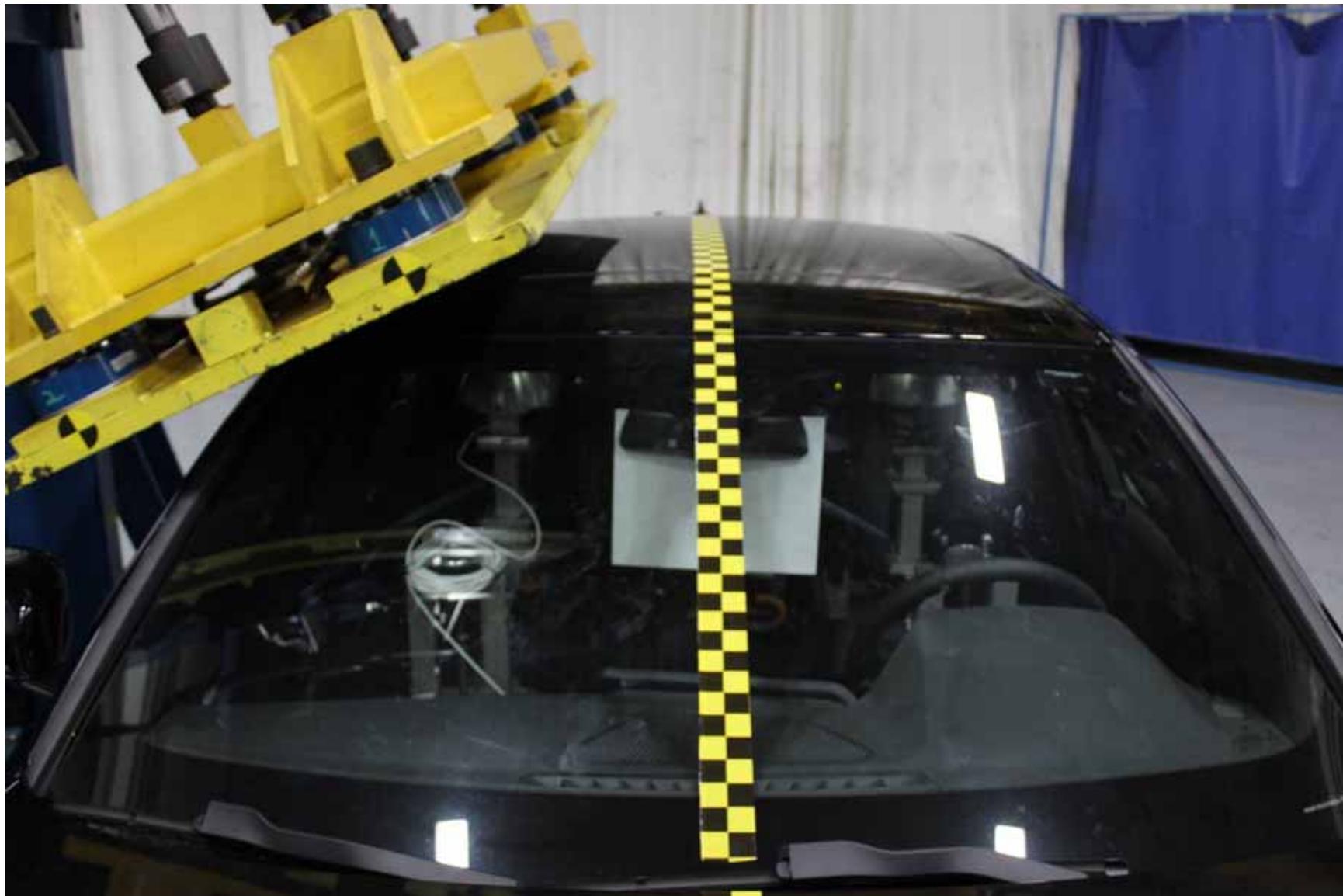
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FMVSS No. 216a

Pre-Test Photograph No. 9 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 10 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 11 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 12 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 13 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 14 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 15 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 16 of Test R20205



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NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 17 of Test R20205



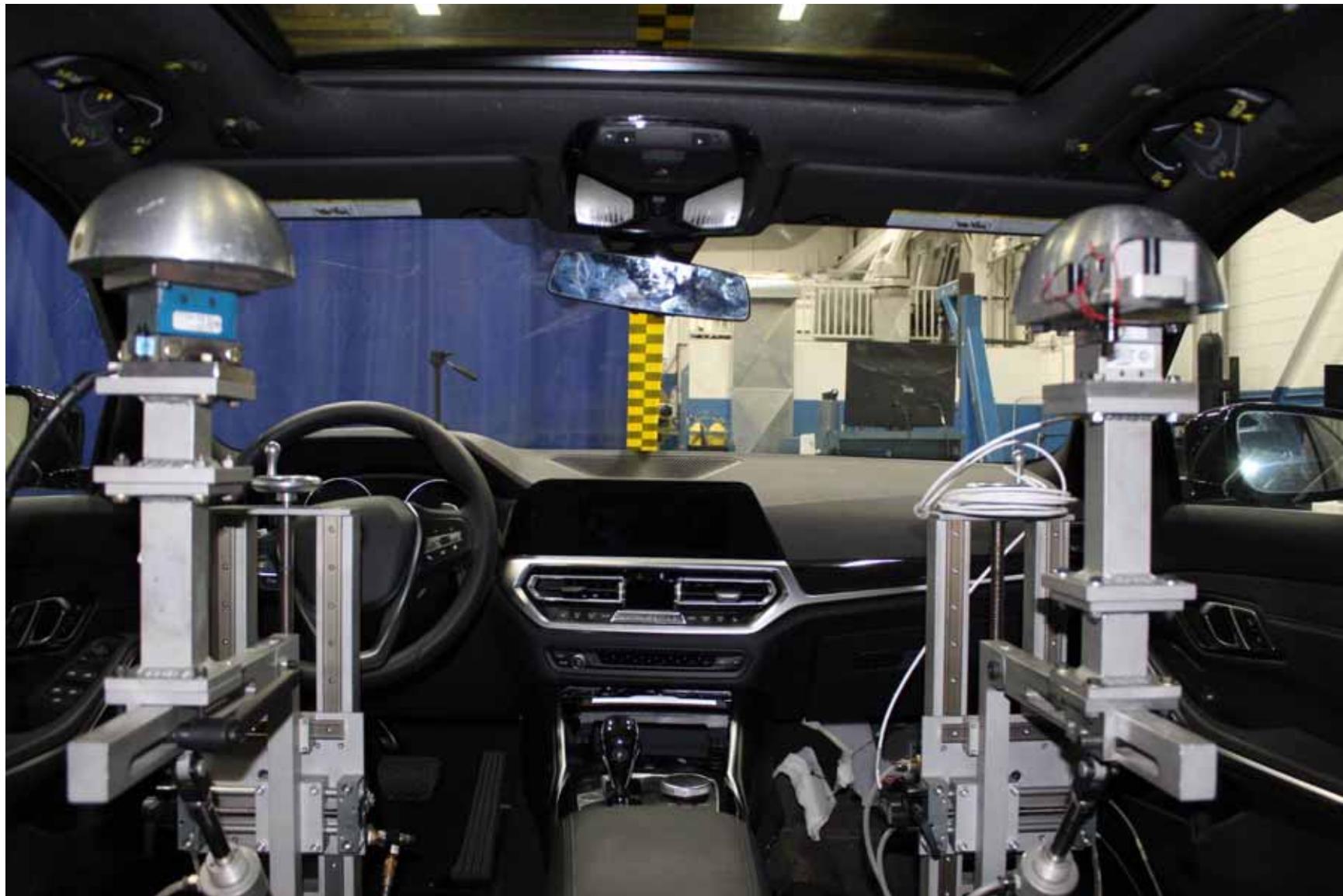
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NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 18 of Test R20205



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NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 19 of Test R20205



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FMVSS No. 216a

Pre-Test Photograph No. 20 of Test R20205



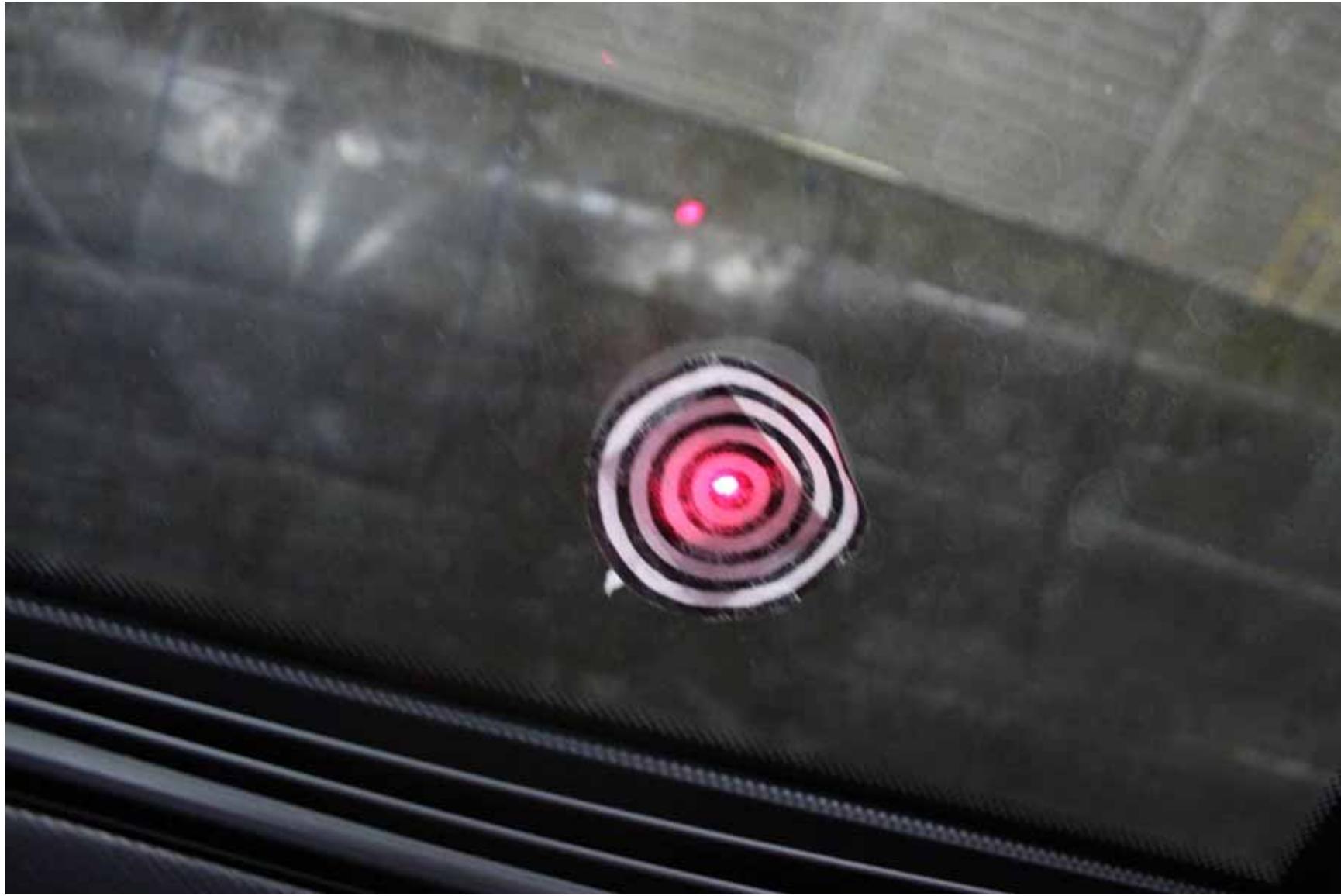
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FMVSS No. 216a

Pre-Test Photograph No. 21 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 22 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 23 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 24 of Test R20205



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NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 25 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 26 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Pre-Test Photograph No. 27 of Test R20205



09/22/20

NHTSA

2020 BMW 3-Series VIN #WBA5R1C0XLFH53825

FMVSS 216a Passenger Side Roof Crush

Contract #DTNH2216D00028 / NHTSA #C20204100

Post-Test

R20205

G19Q7-001.14



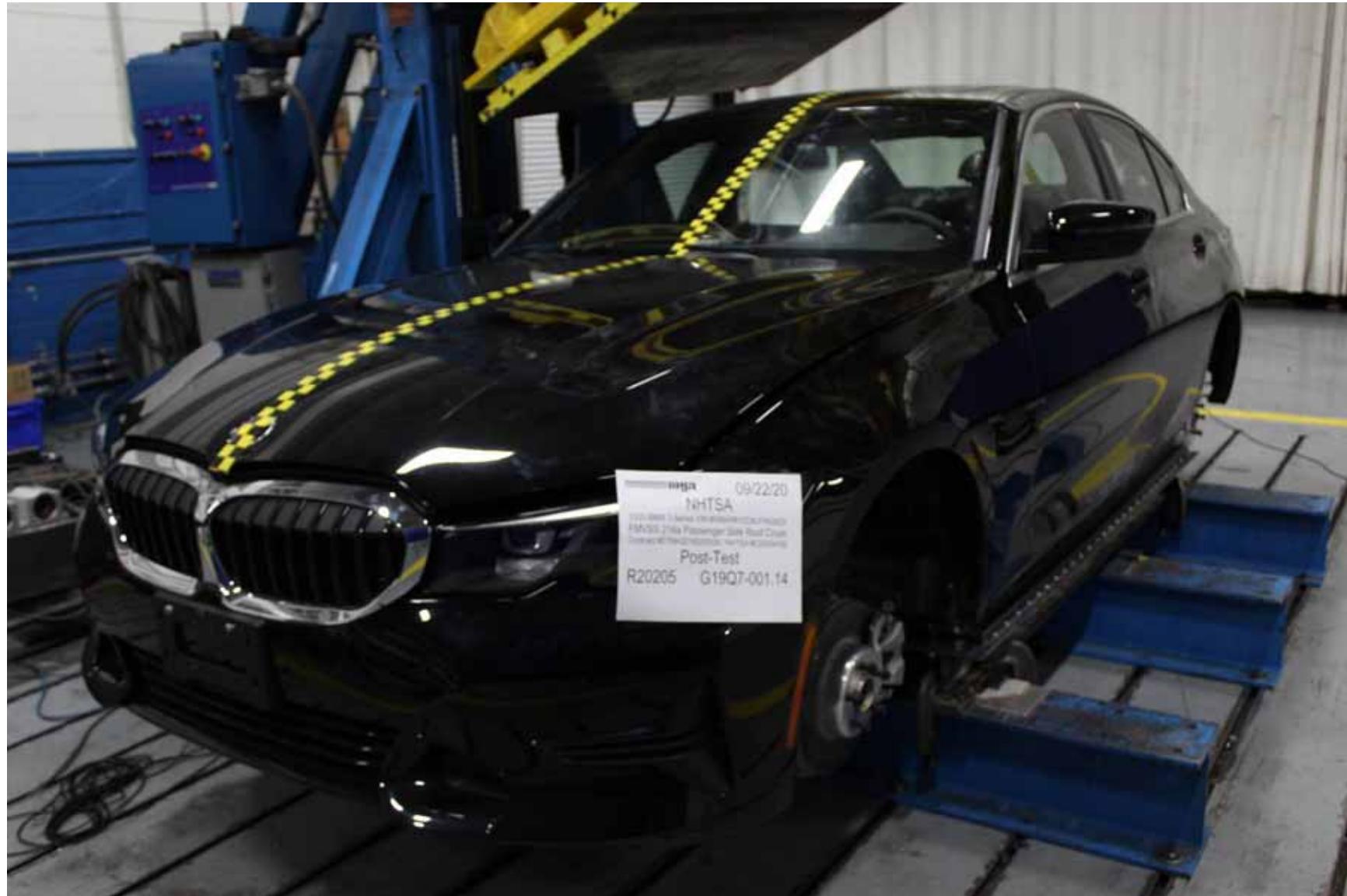
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FMVSS No. 216a

Post-Test Photograph No. 2 of Test R20205



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FMVSS No. 216a

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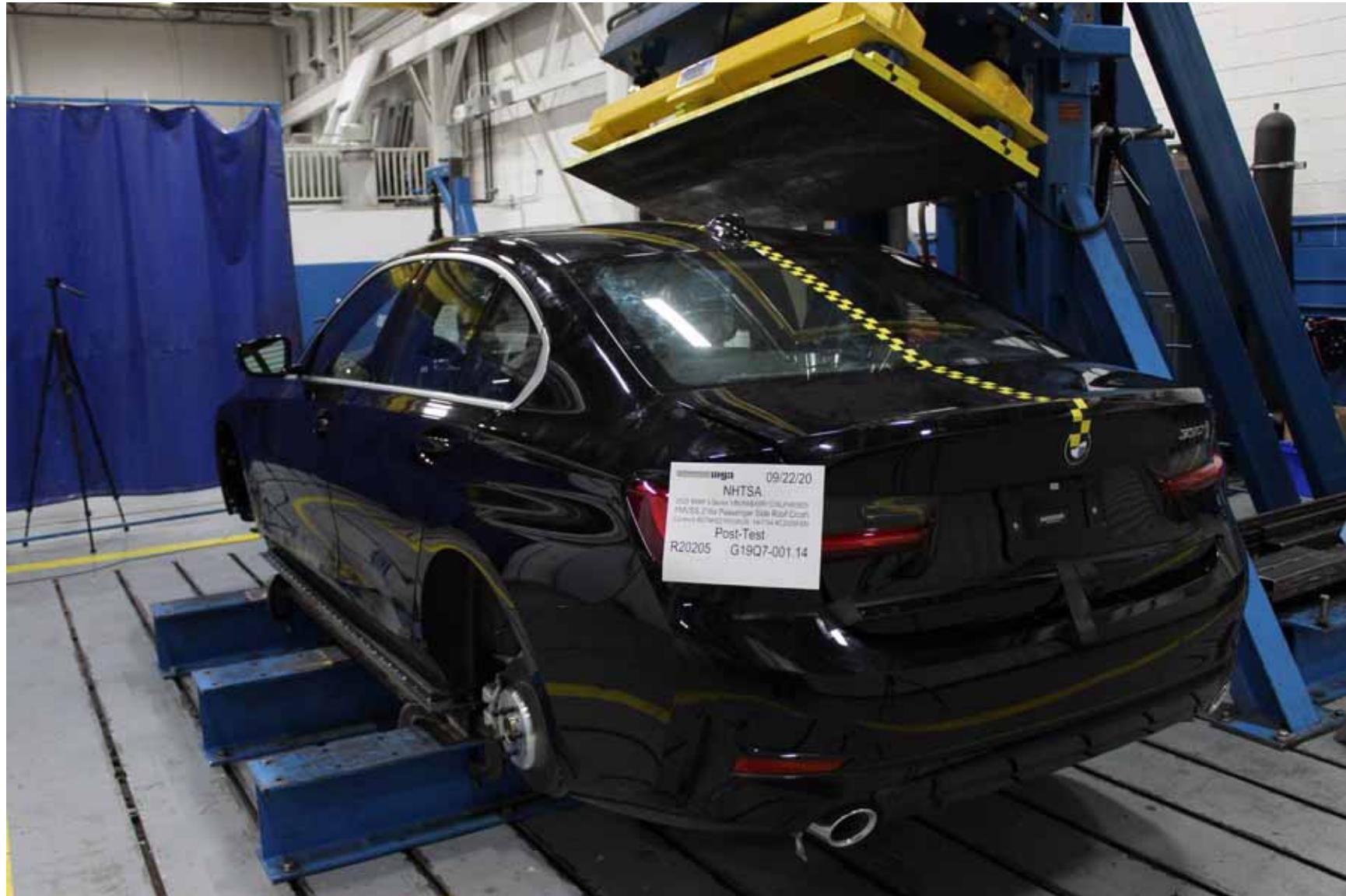
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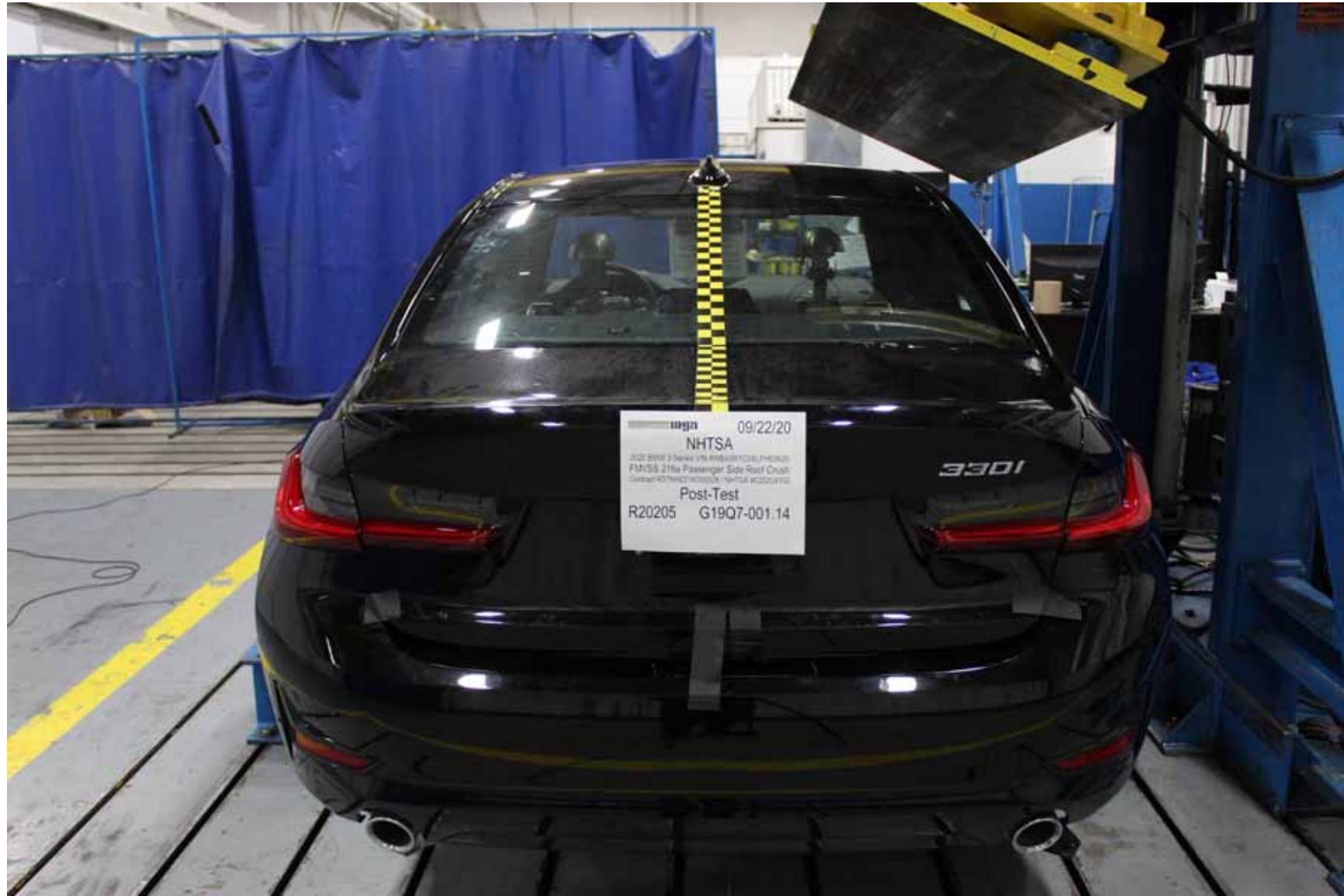
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FMVSS No. 216a

Post-Test Photograph No. 5 of Test R20205



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Post-Test Photograph No. 6 of Test R20205



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FMVSS No. 216a

Post-Test Photograph No. 7 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 8 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 9 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 10 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 11 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 12 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 13 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 14 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 15 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 16 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

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FMVSS No. 216a

Post-Test Photograph No. 18 of Test R20205



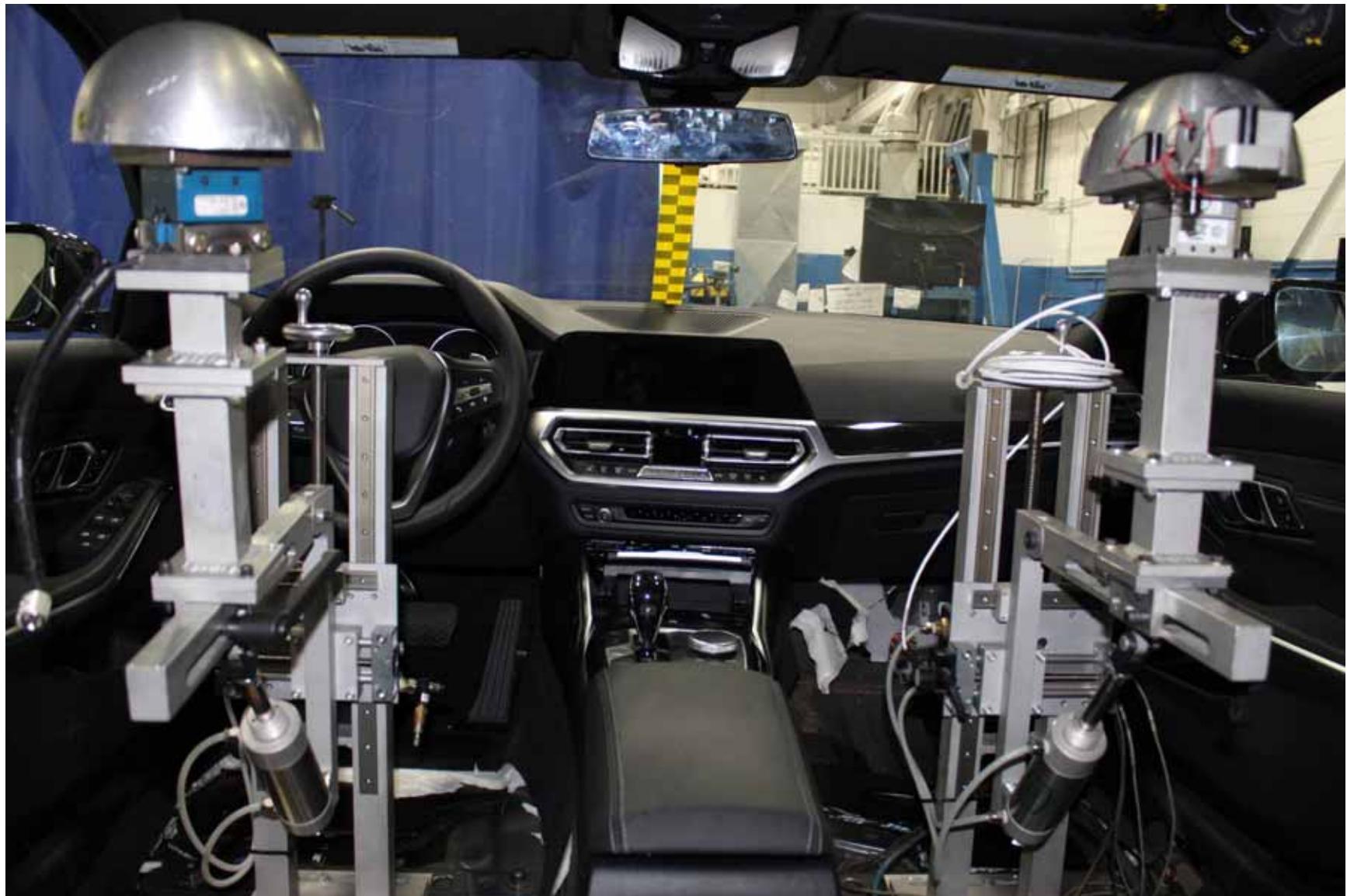
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NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 19 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 20 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 21 of Test R20205



2020 BMW 3-Series
NHTSA No. C20204100
FMVSS No. 216a

Post-Test Photograph No. 22 of Test R20205

6.0 Test Data Plots

